

Atlas of Equine Surgery

Adams & Fessler

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Equine Surgery

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To my parents, for their continued love and support
and for instilling in me a thirst for knowledge;
and to my best friend and loving wife, Emalese.
Philippians 4:4

SBA

To CWM, SBA, HCF, TAT, RRS, MAM, DSW, GRS,
RWC, KRS, KJW, KMK, EDM, and AMR

JFF

Preface

Unlike in the past, contemporary veterinary literature is now replete with excellent general and specific textbooks of equine surgery covering all body systems. It must be asked, why one more book? This atlas is not intended to be a comprehensive tome, but rather a quick reference for practitioners and students who wish to review a familiar operation or to perform a procedure for the first time. If we have been successful, the illustrated plates will stand alone as references to the procedures. If we have been successful, this book will be used during surgery—opened in the operating room on a counter, mounted on a music stand in the corner, or laid in the grass in a field situation. If we have been successful, it will become soiled, literally, with the toils and satisfactions of surgery.

Multiauthored texts present many schools of thought and include many different methods as represented by the backgrounds and experiences of the individual contributors. This atlas represents a single school of thought in that it presents how we currently think about and perform equine surgery. We have described and illustrated those methods that, in our hands, have best stood the test of time or represent unique techniques and approaches that emphasize our ideas and preferences. Most modern surgical procedures are a composite of constantly improving techniques and methods from many different sources. We have endeavored to constantly improve and modify our approach to equine surgery over a collective 63 years of experience.

This atlas does not include every conceivable equine surgical procedure. Long bone fracture repair, arthroscopy, and laparoscopy have been deliberately excluded because of the requirement for expensive equipment, special facilities, advanced training, and an experienced team. Most of the procedures in this atlas can be performed single-handedly, with appropriate technical support, by general large animal or equine practitioners who have a particular interest in surgery, and with equipment and supplies that are already available or easily obtainable in most practice settings. We have included the procedures that are most commonly indicated and used in the everyday care of equine patients.

No textbook is the singular effort of the authors. We are pleased to recognize our colleagues at Purdue University who have provided the time, space, and encouragement to undertake and complete a project like this. The Clerical Services Group of the Department of Veterinary Clinical Sciences was tireless with manuscript preparation. The editorial and production staffs of W.B. Saunders Company, especially Mr. Ray Kersey, were instrumental in initiating the project and professional in their support to complete the work. Finally, and most significantly, we recognize and thank Ms. Felecia Paras for many hours on the road, sometimes through both winter and summer storms, for many days of studying photos, observing demonstrations, and making on-site sketches, and for many months of corrections and changes conjured up by fastidious, perfectionist surgeons. Without her exquisite knowledge of anatomy, superior artistic talent, and perpetual, positive excitement, this book would not be an atlas. It has been a rewarding and enjoyable experience for us.

S.B. ADAMS

J.F. FESSLER

NOTICE

Veterinary medicine is an ever-changing field. Standard safety precautions must be followed, but as new research and clinical experience broaden our knowledge, changes in treatment and drug therapy become necessary or appropriate. Readers are advised to check the product information currently provided by the manufacturer of each drug to be administered to verify the recommended dose, the method and duration of administration, and the contraindications. It is the responsibility of the treating physician, relying on experience and knowledge of the patient, to determine dosages and the best treatment for the patient. Neither the publisher nor the editor assumes any responsibility for any injury and/or damage to persons or property.

THE PUBLISHER

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one

introduction

chapter 1

Patient Preparation

The secret of caring for the patient is caring for the patient.
PEABODY

A complete history and thorough physical examination are the beginning and, frequently, the end of a preoperative evaluation of the equine surgical patient, particularly for an elective, routine surgery such as umbilical herniorrhaphy or castration. Our best diagnostic tool is ourselves! A proficient diagnostician always asks specific questions in the history and practices a methodical physical examination to avoid carelessness and the oversight of a hidden sign that might impact the anesthetic risk or lead to postoperative complications. Regarding the history, the better we know the horse's owner/trainer and the stable, the more accurately we can evaluate the history. We endeavor to inquire about previous coughing or nasal discharge, colic episodes, and the traveling schedule of horses facing elective surgery. It can be risky to anesthetize a horse with influenza or one that is on the verge of experiencing pleuritis. Rhabdomyolysis and salmonellosis are frequent complications in horses stressed by transportation, anesthesia, and surgery. The hyperkalemic periodic paralysis status of large, muscular quarter horses is critical.[1] Not all owners are forthright or even knowledgeable about the genetic background of their horses. It may be prudent to test certain horses for hyperkalemic periodic paralysis before proceeding with an elective surgery.[1]

Surgeons are always in a hurry. We have an intense interest in the problem at hand and frequently fail to examine the whole animal, or even the whole of the body system involved. In addition to examination of the presenting problem, the minimum investigations for a horse undergoing surgery are a record of the temperature, pulse rate, and respiration rate (TPR); auscultation of the chest and abdomen; and assessment of the consistency of the feces. All surgery carries an element of danger, and all anesthesia is merely controlled poison. The TPR and auscultation will alert the surgeon to cardiorespiratory or systemic problems that could impact the plans for elective surgery in a horse that is otherwise presumed to be normal. In an emergency (e.g., fractures, acute abdominal crises), the extent of the history, physical examination, and supporting clinicopathologic data will be determined by the injury or disease in question as well as by the systemic status of the horse.

Most clinically normal horses can be safely subjected to routine elective surgery without the benefit of laboratory tests. However, our practice includes many horses for which the level of management and preventive medicine is unknown or nonexistent. A complete blood count (CBC) to establish a baseline reference has become routine. For outpatients subjected to routine elective procedures, a packed cell volume (PCV) and total solids have been substituted for a CBC. We encounter many horses, particularly foals, with a stress leukogram, presumably as a result of transportation, and no other abnormality. A white blood cell (WBC) count greater than 12,000/mm^3 is viewed with suspicion. Similarly, a hemoglobin less than 10 g/dl or a PCV less than 30% will be brought to the owner's attention before we proceed with anesthesia and surgery. Occasionally, a fecal examination is performed as the first step in identifying a cause for anemia, particularly when the deworming history is unknown. The need for additional laboratory studies, including electrolytes, enzymes, or pH and blood gases, will be determined by the medical status of the horse (e.g., acute abdominal crises).

Today, compared with 10 to 20 years ago, we are performing more procedures on an outpatient basis. However, when major elective procedures requiring inhalation anesthesia and aseptic technique are planned, the horse is admitted to the hospital the day before surgery. Horseshoes are removed and the animal is thoroughly groomed, including vacuuming. Dirty horses are bathed; for major elective orthopedic procedures, bathing should be considered routine. Careful grooming and bathing help control the viable particle count in the surgical amphitheater.

Except for lactating mares, grain feeding is withheld throughout the period of hospitalization, and all feed is withheld 6 hours before surgery. We are not concerned about early morning hay consumption by horses scheduled for afternoon surgery or about straw bedding consumption. Water is allowed ad libitum. When major abdominal procedures are planned (e.g., mesh repair of ventral hernias), all feed and edible bedding can be withheld for up to 72 hours without compromising the nutritional status of the horse. Such feeding changes do alter the gastrointestinal microflora

and microfauna and may predispose the horse to salmonellosis. For most surgical procedures, normal feeding can resume within 2 hours of recovery from general anesthesia. After gastrointestinal surgery, watering, feeding, and bedding practices are determined by the intraoperative findings and the physiologic status of the patient. For these horses, we use shavings for bedding, frequently use a muzzle, and withhold all feed and water for at least 12 to 24 hours or until nasogastric reflux and postoperative ileus subside.

When possible, the surgery site should be clipped and shaved before induction of anesthesia in order to save operative time, but not earlier than 2 hours before surgery and never the day before. Clipper and razor burns fester easily, increasing the bacterial population at the incision site. Clipping with a size 40 Oster clipper head[a] removes sufficient hair to ensure proper antisepsis of the skin. However, for areas where the skin surface is smooth enough to shave without marked nicking, we prefer to shave the line of incision after clipping. Incision through clipped skin that has not been shaved carries hair bristles into the deeper tissues. Disposable razors are effective for shaving equine skin.[b]

A wide area surrounding the incision site should be clipped and surgically scrubbed in anticipation of the contingencies that frequently accompany equine surgery. Skin should be surgically prepared at least 12 inches beyond the anticipated margins for draping. For limbs, the entire circumference of the limb should be prepared. This facilitates intraoperative palpation and orientation to adjacent structures without breaking asepsis. Ventral abdominal incisions frequently are lengthened after an exploratory laparotomy has been started. For horses with colic, we routinely clip and scrub from the pubis rostrally beyond the xiphoid cartilage and laterally beyond the flank folds. Foals are prepared in a similar fashion for umbilical remnant resection in the event that the hepatic vein, as well as the urachus and umbilical arteries, is involved. Many colts have little or no hair over the inguinal rings, and the noninvasive cryptorchidectomy can be performed without clipping. However, in the event of unexpected findings, such as monorchidism[2] or a testicular tumor, the inguinal approach cannot be converted to a suprapubic paramedian laparotomy approach through the same skin incision without previous clipping and scrubbing of the adjacent site.

Povidone-iodine, 7.5% surgical scrub[c] or chlorhexidine gluconate, 4% antimicrobial skin cleanser[d] is a suitable product for routine scrubs to prepare for aseptic surgery in the horse. The occasional horse is sensitive to povidone-iodine, and urticaria may develop at the site. Some personnel are sensitive to iodine products as well. Povidone-iodine and chlorhexidine are viscous products and can be diluted up to 50% with distilled water to improve handling properties without sacrificing their antimicrobial capabilities. The scrub should be vigorously applied to the surgery site for 5 to 7 minutes using sterile 4 × 4-inch gauze sponges. If the hoof capsule is involved, the foot is trimmed closely and a sterile hand brush is used to scrub. We use three separate scrubs, each followed by an alcohol rinse with 70% isopropyl alcohol[e] during the scrubbing process. The person performing the final scrub in the surgical amphitheater should be suitably attired with scrub suit, cap, and mask. The centrifugal scrubbing pattern is critical and is conducted in a way to optimize disinfection at the incision site (Fig. 1–1). The person performing the scrub should never backtrack to the central portion of the scrub area with the gauze pads that have been in contact with the peripheral portions that have been clipped. The scheme of the entire operating room protocol—scrubbing, draping, ventilation, circulating personnel—is to create and maintain the highest level of antisepsis at the operative site.

Tetanus prophylaxis should be ensured. Even though the aim of all modern surgery is to leave the tissues in an aerobic state that would preclude the germination of tetanus spores, tetanus has been known to follow routine surgical procedures such as castration. If the vaccination status of the horse is known to be current, a tetanus toxoid booster is not required at surgery. The best protection of young foals is provided by immunization of the pregnant mare followed by colostrum ingestion at birth. For older foals that have not had the complete vaccination series, tetanus toxoid is administered at surgery. For older horses, tetanus toxoid is administered if the last booster was more than 12 months before. When surgically treating contaminated wounds, particularly punctures, we always administer tetanus toxoid, if for no other reason than to provide evidence of protection in the medical record. Tetanus antitoxin is rarely, if ever, used anymore in our practice.

An important but indirect part of patient preparation is informing owners of potential complications, possible consequences, and the outcome in terms of the expected percentage return to performance after surgery. The risks associated with anesthesia and the possibility of infection, however slight, should always be mentioned, if not discussed at length. The current literature is increasingly replete with the "percentages" of outcomes for many equine surgical procedures. Results are available for various types of colic surgery and for the chances for marginal, equivalent, or superior racing

[a]Size 40 blade replacement, Oster Professional Products, McMinnville, TN.

[b]Preptic disposable razor, Johnson & Johnson Medical Inc., Arlington, TX.

[c]Betadine surgical scrub, Purdue Frederick Co., Norwalk, CT.

[d]Hibiclens, Zeneca Pharmaceuticals Inc., Wilmington, DE.

[e]Isopropyl alcohol, 70%, Bergen-Brunswig, South Bend, IN.

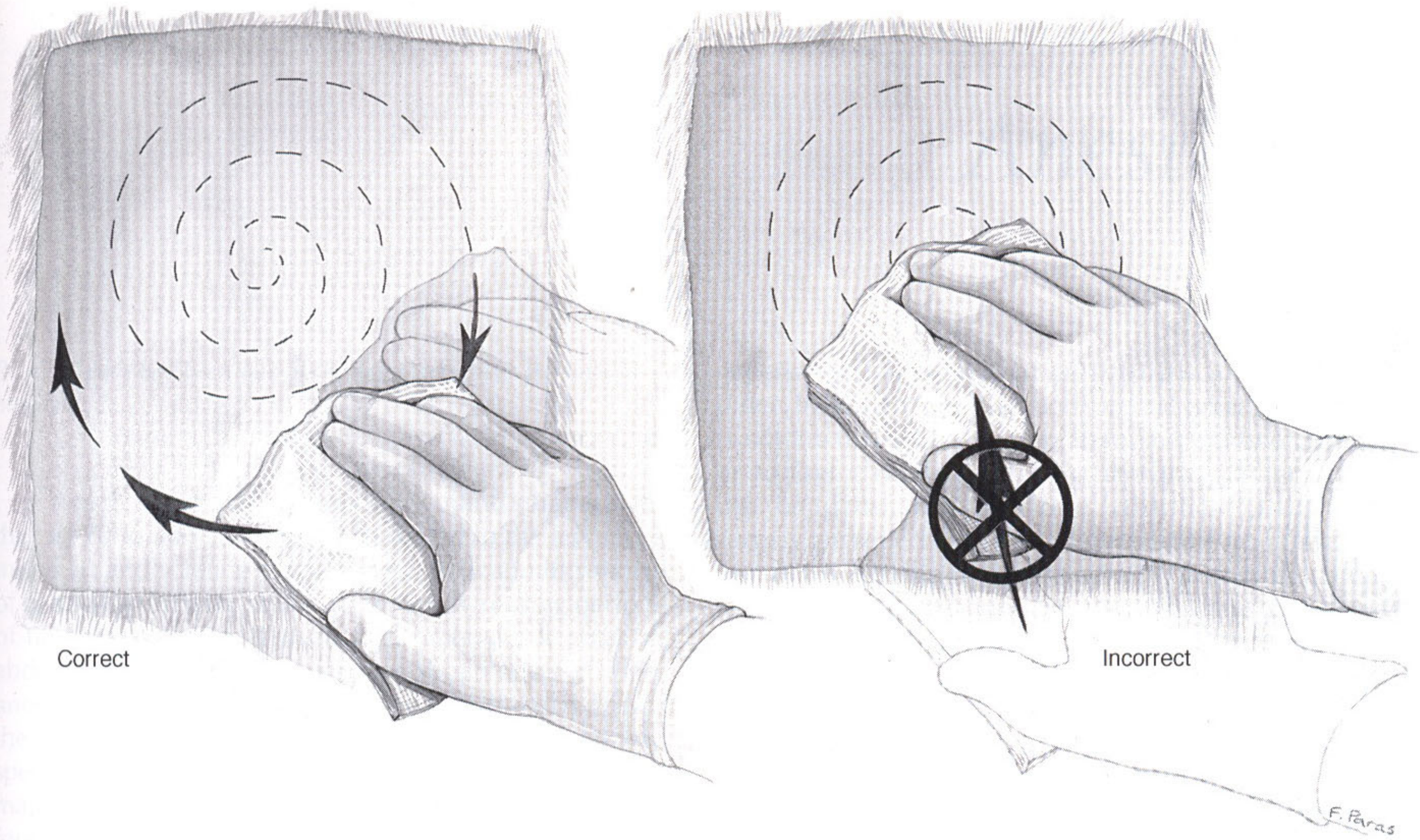


Figure 1–1.

performance after various orthopedic procedures in racehorses. We have endeavored to include these percentages for the procedure in question when discussing surgery with owners. The surgeon must be prepared and willing to share the results from previous cases and to put these results in perspective when helping an owner reach a decision about surgery. Laypeople often decide to proceed with surgery even though problems have been identified and the percentages for a favorable outcome are marginal. They more readily accept less than optimal results from surgery, or from the horse when the animal returns to a performance status, if they have been so prepared from the outset.

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1. Bailey JE, Pablo L, Hubbell JAE: Hyperkalemic periodic paralysis episode during halothane anesthesia in a horse. J Am Vet Med Assoc 1996;208(11):1859.
2. Santschi EM, Juzuriak JS, Slone DE: Monorchidism in three colts. J Am Vet Med Assoc 1989;194(2):265.

chapter 2

Anesthesia

Relief of pain has been one of the most persistent pursuits of mankind.

SMITHCORS

Much of the advancement in equine surgery over the last 20 to 30 years can be attributed to the advances in the art and science of anesthesia. Safe administration of general anesthesia in the horse, for increasing periods of time (hours), has allowed phenomenal advances in abdominal and orthopedic surgery. When one considers anesthesia for what it is—controlled poison—it is one of the miracles of medicine. Anesthesiology is a veterinary specialty, and its in-depth science is the subject of major textbooks.[1–3] However, every veterinarian performing equine surgery must have fundamental knowledge of the pharmacology of sedative and anesthetic agents, anesthetic equipment and its use, and anesthetic monitoring in order to conduct and supervise anesthesia and to deal with anesthetic emergencies when they arise. The surgeon is the leader of the operative team. The surgeon is responsible for selecting the anesthetic method to be used (i.e., local, regional, general). Table 2–1 provides a guideline for the anesthetic methods that are useful and recommended for the procedures in this atlas. The remainder of this section addresses the decision-making process for selecting an anesthetic method and identifies our preferences for selected procedures.

Selecting the operative site and planning the restraint and anesthesia are integral to the successful performance of surgery and, most especially, to a successful outcome for the horse. All of the procedures described in this atlas can be performed in locations other than a university-based hospital, provided that an equine surgical facility with appropriate equipment is available. Many procedures can be done on the farm or at the stable. Separate induction/preparation, surgery amphitheater, and recovery rooms provide the ideal traffic pattern for the equine patient and the operative team but are not always cost-effective or essential. Anesthetic induction, surgical preparation, the operation itself, and recovery are commonly performed in a single room. Essential are a "state of readiness" and a flow of work that facilitates safety for the horse and for the operative personnel and that facilitates the level of asepsis mandated by the procedure. Whether performed in a major hospital, in a single room, or in the field, all necessary equipment must be available and in working order. When an anesthetic or surgical emergency arises is not the time to hunt for an item that has been mislaid or to find it broken. Clipping, shaving, and scrubbing can be done with the horse in a final position for surgery provided that hair is vacuumed from the area and other activities are conducted in a centrifugal pattern away from the incision site. Selecting the proper location and environment for performing surgery on the standing, conscious horse is critical to the safety and success of the procedure. The horse must have nonslip footing, and noise and commotion in the environment should be reduced. A calm, properly sedated, and restrained or anesthetized horse and a calm, thoroughly prepared operative team are far more important to the success of surgery than the location or facilities per se.

Table 2–1 indicates procedures in this atlas that can be performed under local anesthesia with the horse standing or under general anesthesia. For example, sternothyrohyoideus myectomy, when performed as the only treatment for dorsal displacement of the soft palate, can be easily performed on the standing horse. When the myectomy is combined with laryngotomy and staphylectomy, general anesthesia is required, and both procedures are done simultaneously. Similarly, palmar digital neurectomy can be performed at the same time as diagnostic anesthetic nerve blocks with the horse standing. Alternatively, some surgeons prefer to wait for the tissue irritation and inflammation associated with a diagnostic nerve block to subside before performing a neurectomy; regional anesthesia, with the local anesthetic agent being injected remote (proximal) to the incision site, permits surgery on the standing horse and avoids additional local irritation. Although it is more costly, we recommend general anesthesia for palmar digital neurectomy to facilitate aseptic technique, careful sharp dissection, good hemostasis, and fastidious suturing, all with the intent of avoiding painful neuromas.

Forty years ago, much surgery was performed on the standing horse using physical restraint and local anesthesia because reliable general anesthesia was not yet available. Chloral hydrate and a casting harness helped to accomplish tasks but could not be considered safe general anesthesia. At that time, phenothiazine-derivative tranquilizers were unreliable and were associated with adverse reactions, and local anesthetic

Table 2–1.

Anesthetic Methods

Type of Surgery	Method
Skull, Head, and Neck	
Sinus trephination	L
Frontonasal flaps	G (I)
Extraction and repulsion of cheek teeth	G (I or IV)
Repair of facial fractures	G (I or IV)
Repair of mandibular/maxillary fractures	G (I or IV)
Dentigerous cyst excision	G (I)
Modified Forssell's operation	G (I)
Gastrointestinal	
Esophagotomy	G (I or IV)
Cervical esophagostomy	L, G (I or IV)
Ventral midline celiotomy	G (I or IV)
Enterotomy	G (I)
Intestinal resection and anastomosis	G (I)
Large colon resection	G (I)
Colopexy	G (I)
Flank laparotomy	L, G (I or IV)
Loop colostomy	L, G (I)
Indwelling rectal liner	G (I)
Rectal prolapse	E, G (I)
Respiratory	
Excision of nasal epidermal inclusion cysts	G (I or IV)
Resection of alar folds	G (I)
Laryngotomy/sacculectomy	L, G (I or IV)
Laryngoplasty	G (I)
Arytenoidectomy	G (I)
Sternothyrohyoideus myectomy	L, G (I or IV)
Staphylectomy/epiglottic augmentation	G (I or IV)
Treatment of epiglottic entrapment	G (IV)
Excision of subepiglottic cysts	G (I or IV)
Approach to guttural pouch	G (I or IV)
Fenestration of medial septum of the guttural pouch	G (I)
Ligation of internal carotid artery	G (I)
Tracheotomy	L
Ophthalmic	
Subpalpebral lavage	R, G (IV)
Entropion surgery	G (IV)
Third eyelid excision	L, G (IV)
Transpalpebral enucleation	G (I or IV)
Correction of nasolacrimal duct atresia	L, G (I or IV)
Male Reproductive System	
Castration	L, G (IV)
Cryptorchidectomy	G (I or IV)
Inguinal herniorrhaphy	G (I or IV)
Penile amputation	G (I)
Female Reproductive System	
Caslick's procedure	L, E
Urethral extension for vesicovaginal reflux	E
Rectovestibular fistula repair	E
Third-degree perineal laceration repair	E
Ovariectomy by colpotomy	E
Ovariectomy by laparotomy	G (I or IV)
Cesarean section	G (I)
Urinary	
Resection of umbilical cord remnants	G (I)
Ruptured urinary bladder repair	G (I)
Perineal urethrotomy	E
Suprapubic laparocystidotomy	G (I)
Fracture Repair	
Lag screw fixations	G (I)
Lag screw fixation of third carpal slab fractures	G (I)
Repair of condylar fractures	G (I)
Repair of proximal phalangeal fractures	G (I)
Excision of apex of proximal sesamoid	G (I)
Excision of distal splint bone fractures	G (I or IV)
Osteostixis	G (I or IV)
Harvesting cencellous bone grafts	G (I)
Half-limb cast	G (I or IV)
Half-limb cast with transfixion	G (I)
Full-limb cast	G (I or IV)
Musculoskeletal System	
Palmar digital neurectomy	L, R, G
Navicular suspensory desmotomy	G (I or IV)
Navicular bursotomy	G (I)
Arthrodesis of the proximal interphalangeal joint	G (I)
Palmar/plantar annular ligament division	R, G (I or IV)
Resection of carpal flexor retinaculum	G (I or IV)
Distal check desmotomy	G (I or IV)
Proximal check desmotomy/percutaneous tendon splitting	G (I)
Deep digital flexor tenotomy	R, G (IV)
Periosteal stripping	G (I or IV)
Transphyseal bridging	G (I)
Cunean tenectomy	L
Arthrodesis of distal tarsal joints	G (I)
Semitendinosus tenotomy	G (I)
Lateral digital extensor myotenectomy	L, G (IV)
Medial patellar desmotomy	L
Suprascapular nerve decompression	G (I)
Regional antibiotic perfusion	R, G (I or IV)
Abdominal Wall	
Umbilical herniorrhaphy	G (I or IV)
Mesh repair of large body wall defects	G (I)
Integumentary	
Pinch grafting	L
Tail amputation	E

L, local infiltration; R, regional anesthesia; E, epidural anesthesia; G, general anesthesia; I, inhalation; IV, intravenous.

agents such as procaine hydrochloride were slow to take effect, irritating to the tissues, and short-lasting. With the advent 30 years ago of the fluorinated hydrocarbons, inhalation anesthesia has become routine for many of the procedures that were previously performed on the standing horse (e.g., laryngotomy and sacculectomy). In the last 10 to 15 years, xylazine hydrochloride,[a] butorphanol tartrate,[b] and detomidine hydrochloride[c] have revolutionized chemical restraint of the standing horse. Although these prescription drugs do have limitations, they are relatively inexpensive and free of serious complications when used correctly. Similarly, local anesthetic drugs such as mepivacaine hydrochloride[d] take effect rapidly, last longer, and are less irritating than older products. With the availability of these drugs, we are again performing more surgical procedures on the standing horse as a matter of cost saving and convenience, yet without completely sacrificing safety. Currently, the selection of physical restraint compared with chemical restraint is dependent on the level of horsemanship of the handler (i.e., the person "on the head"), the disposition of the horse, and the comfort level of the veterinarian. In our teaching hospital, sedation has become routine, even for minor, noninvasive techniques such as radiographic positioning.

Selecting chemical restraint drugs and determining the dosage for horses undergoing standing surgery, particularly when several drugs are used in combination, requires experience. For example, some mares that are accustomed to rectal palpation and perineal manipulation stand better for rectovaginal surgery without any sedation. The chemical restraint drugs, all of which provide some degree of analgesia, are no substitute for an effective epidural, but they can be used in light doses to quiet a restless or apprehensive mare. Alternatively, deep sedation combined with epidural anesthesia can lead to such unsteadiness and weight shifting as to make perineal surgery impossible. Similarly, for standing distal limb surgery (e.g., deep digital flexor tenotomy), the horse needs to be "planted to the ground" while still allowing for one leg to be raised. Too much unsteadiness in the horse will make the surgery difficult and decrease the safety. The surgeon must be judicious about proceeding in such circumstances and be prepared, on occasion, to abort the procedure and reschedule the surgery when the combination of chemical restraint and local or regional anesthesia is not satisfactory.

Local Infiltration

For many procedures that can be performed on the standing horse (e.g., cunean tenectomy, flank laparotomy, Caslick's procedure), we practice direct infiltration of the incision site with 2% mepivacaine hydrochloride. A skin bleb can be created first with a 25-gauge needle, and subsequent injections are made with a 20-gauge needle inserted through previously numbed skin. Anesthetic solution is injected ahead of the needle by maintaining steady pressure on the syringe plunger as the needle is advanced through the tissue. With proper restraint and patience, most horses tolerate this technique of injection. Most procedures that are done on the standing horse require nominal amounts, 20 ml or less, of local anesthetic. For major procedures (i.e., standing flank laparotomy), the total volume of local anesthetic agent should not exceed 100 ml to avoid the threat of systemic toxicity. The tissue edema created by local infiltration does camouflage the landmarks, but it helps to control capillary bleeding during surgery. Concerns about a local anesthetic agent's interfering with healing, when used by local infiltration, have not been a problem in our experience. Complications such as infection or wound breakdown, when they have occurred, have been attributable to far more glaring surgical errors than the local infiltration of the anesthetic agent.

Caudal Epidural

Caudal epidural anesthesia in the horse facilitates a number of perineal procedures (see Table 2–1). The injection site is selected by slowly pumping the tail up and down while palpating the depression between the sacral (S) and first coccygeal (C) vertebrae or between the first and second coccygeal vertebrae on the dorsal midline just rostral to the long hairs of the tail. The first space for which the vertebrae can be felt to move on either side is used. Usually, the most prominent depression occurs between C-1 and C-2. The injection site should be determined before the hair is clipped, which may change the landmarks. The injection can be made with a straight 18-gauge, 1.5-inch needle, such as in the cow, or with an 18-gauge, 3.5-inch curved spinal needle threaded into the epidural space (Fig. 2–1). The horse is twitched, and 1 to 2 ml of local anesthetic solution is injected to create a skin bleb and subcutaneous anesthesia before aseptic insertion of the epidural needle. Midline orientation is essential. Proper positioning of the needle can be determined by the free flow of anesthetic solution when dropped into the needle hub (see Fig. 2–1) and by the lack of pressure on the syringe plunger as anesthetic is injected. When the short needle is used, there may be incomplete desensitization of the perineal region with poor rostral diffusion of the anesthetic agent. Horses that have had previous epidural injections frequently experience incomplete desensitization, apparently because of a chemically induced adhesive arachnoiditis in the coc-

[a]Rompun, Bayer Corp., Shawnee Mission, KS.
[b]Torbugesic, Fort Dodge Laboratories, Inc., Fort Dodge, IA.
[c]Dormosedan, Pfizer Inc., New York, NY.
[d]Carbocaine—V, The Upjohn Co., Kalamazoo, MI.

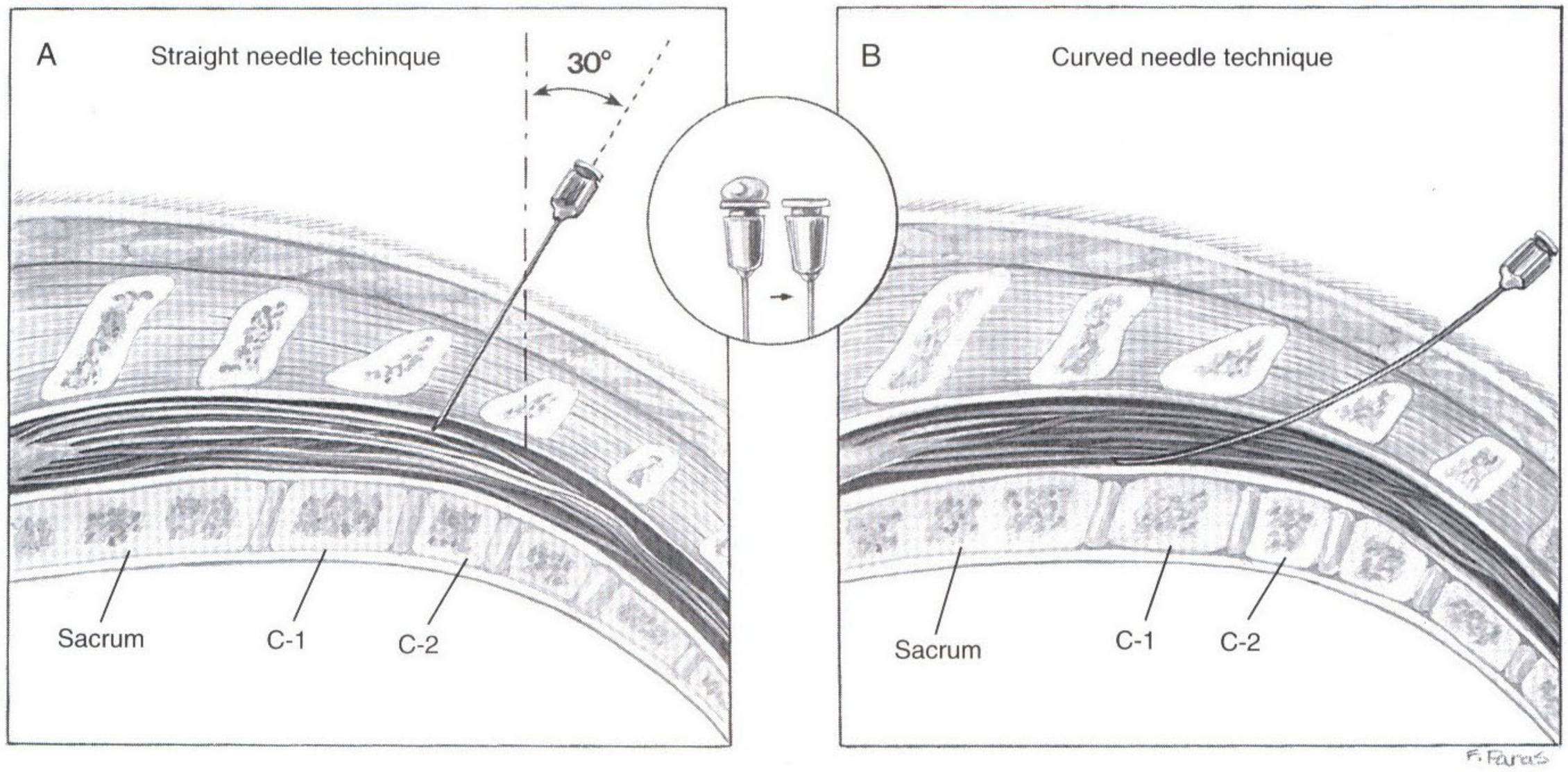


Figure 2–1.

cygeal region. These problems can be circumvented by threading the spinal needle rostrally in the epidural canal from the S-5 to C-1 or C-1 to C-2 intervertebral space (see Fig. 2–1). Up to 8 ml of 2% mepivacaine hydrochloride can be deposited at this site without fear of recumbency in an adult horse. The epidural lasts up to 90 minutes. The needle with stylet can be left in position to augment anesthesia during surgery.

Xylazine hydrochloride, 0.17 mg/kg diluted to a 10-ml volume, provides excellent, safe epidural analgesia lasting over 2 hours.[4, 5] This drug requires 20 to 30 minutes to take effect but is not accompanied by hindlimb ataxia. The xylazine can be combined with up to 5 ml of 2% local anesthetic, which is then diluted to a 10-ml volume.[6] This combination of drugs takes effect significantly more rapidly than xylazine alone and lasts significantly longer, up to 5 hours.[6] We prefer this combination to either drug alone and find that it creates reliable perineal analgesia without requiring use of the spinal needle in most cases.

General Anesthesia

General anesthesia provides complete restraint and unconsciousness and, depending on the depth, profound analgesia and muscular relaxation. Basal anesthesia is a light level of general anesthesia commonly produced by the intravenous administration of a preanesthetic agent followed by an induction agent (e.g., xylazine followed by ketamine hydrochloride).[e] Basal anesthesia is used widely in equine surgery for the performance of many short, elective procedures (e.g., castration) and to initiate deeper anesthesia by the administration of other agents, usually the inhalants. Basal anesthesia can be extended up to 1 hour or more by the continuous administration of a combination of drugs, usually including guaifenesin,[f] to create general anesthesia. Surgical anesthesia, as provided by the fluorinated hydrocarbons halothane[g] and isoflurane,[h] allows surgery to be performed painlessly and without struggling by the patient. Such inhalation anesthesia is routine for all major abdominal, musculoskeletal, and upper respiratory surgery in the horse. Currently, four American companies provide large-animal anesthetic rebreathing circuits with supporting equipment and supplies; these companies are listed in Table 2–2.

[e]Ketaset, Fort Dodge Laboratories, Inc., Fort Dodge, IA.

[f]Gecolate, Summit Hill Labs, Navesink, NJ.
[g]Halothane USP, Halocarbon Laboratories, River Edge, NJ.
[h]Iso Flo, Solvay Animal Health, Inc., Mendota Heights, MN.

Table 2–2.

Large-Animal Anesthetic Machines

1. LDS 3000 large-animal anesthesia machine, SurgiVet/ Anesco, Waukesha, WI
2. Vet-Tec Model LAVC-2000, JD Medical Distributing Co., Inc., Phoenix, AZ
3. Model 2800 large-animal anesthesia system, Mallard Medical, Inc., Redding, CA
4. VML anesthesia machine, MDS Matrix, Orchard Park, NY

The selection of intravenous general anesthesia or inhalation general anesthesia for a particular equine patient or surgical procedure is dependent on the nature and length of the surgery, the volume of surgical patients in the practice, and the skill, experience, and speed of the surgeon (see Table 2–1). Intravenous anesthesia is relatively inexpensive compared with the necessary outlay for equipment for inhalation anesthesia and affords many veterinarians the option of performing surgery in their practice. Nearly one half of the procedures described in this atlas can be safely and conveniently performed with basal intravenous anesthesia, and many other procedures can be performed with extended general intravenous anesthesia if the surgeon is experienced. Although we recommend and prefer inhalation anesthesia for major procedures, there are experienced, busy equine surgeons who rely completely on the intravenous route for anesthesia, even for major abdominal surgery and procedures such as arthroscopy. Recovery of the horse from intravenous anesthetic agents, particularly when the anesthesia has been extended, can be more prolonged and excitable than recovery after inhalation anesthesia. Regardless of the cost, inhalation anesthesia is recommended for high-volume modern equine surgical practices if for no other reasons than to enhance safety and improve recoveries.

All surgeons should endeavor to use the lightest plane and shortest duration of general anesthesia compatible with the safe, convenient performance of the procedure. Combinations of local, regional, and general anesthesia should be used when the combined approach will permit a lighter plane of general anesthesia. For example, many orthopedic procedures create bone pain, which requires deep surgical anesthesia. A regional nerve block, at the level of the proximal sesamoid bones, will reduce the required depth of general anesthesia for a procedure such as navicular bursotomy.

All general anesthesia in the horse, including intravenous anesthesia, should include the establishment of venous access by catheterization and of an airway by orotracheal intubation. These are routine precautions in the event of an anesthetic emergency. The ready availability of oxygen, a demand valve,[i] and myocardial stimulatory drugs is essential, even in field situations. Table 2–3 is an inventory of drugs and equipment that should be immediately available whenever and wherever horses are anesthetized. They fit in a standard toolbox, which can serve as a "crash kit." All general anesthesia procedures extending beyond 30 to 45 minutes should include the measurement of blood pressure in addition to the monitoring of clinical signs. Simple, inexpensive methods for the direct[j] and indirect monitoring of blood pressure are available. The use of other methods of monitoring horses under general anesthesia, including the levels of expired gases and blood pH and blood gases, will depend on the sophistication of the hospital and the type and complexity of surgical patients accepted into the practice. In the final analysis, the circumstances surrounding a particular equine patient, the experience of the surgeon, and the wishes of the owner help to determine the anesthetic method to be used.

Table 2–3.

Emergency Drugs and Supplies

Equipment
Scalpel handle and blade
Tracheotomy tube
Needles/syringes/catheters
Drugs
Atropine sulfate
Calcium
Dexamethasone
Dobutamine hydrochloride
Doxapram hydrochloride
Epinephrine hydrochloride
Furosemide
Lidocaine hydrochloride
Prednisone sodium succinate
Propanolol hydrochloride
Sodium bicarbonate
Yohimbine hydrochloride

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3. Thurmon JC, Tranquilli WJ, Benson GJ: Lumb & Jones' Veterinary Anesthesia, 3rd ed. Baltimore, MD: Williams & Wilkins, 1996.
4. LeBlanc PH, Caron JP, Patterson JS, et al: Epidural injection of xylazine for perineal analgesia in horses. J Am Vet Med Assoc 1988;193(11):1405.
5. LeBlanc PH, Caron JP: Clinical use of epidural xylazine in the horse. Equine Vet J 1990;22(3):180.
6. Grubb TL, Riebold TW, Huber MJ: Comparison of lidocaine, xylazine, and xylazine/lidocaine for caudal epidural analgesia in horses. J Am Vet Med Assoc 1992;201(8):1187.

[i]Demand Value, model 5040, Hudson Oxygen Therapy, Inc., Temecula, CA.

[j]Sphygmomanometer Gauge, American Diagnostic Corp., West Babylon, NY.

chapter 3

Draping

Aseptic technique should not be attempted as a half-hearted measure; rather, it should be employed in a most rigid manner.

ARLEIN

Draping is one of the components of aseptic technique. Drapes isolate surgically exposed tissues from surrounding skin and surface anatomy. Draping is beneficial for controlling or eliminating bacterial contamination of the operative field. There is little or no premise for using drapes if any or all of the other components of aseptic technique are ignored. Conversely, there are practical reasons for using autoclaved instruments, sterile supplies, and gloves in the absence of draping. Appropriate recommendations about necessary aseptic technique are a part of the description of each of the procedures in this atlas.

For many procedures that can be performed on the standing horse, drapes can be an impediment, but cleanliness is fundamental to any surgical technique. Drapes that shift or become dislodged can increase the potential for contamination by dragging hair and bacteria from the surrounding unprepared skin surfaces onto the operative field. Self-adhering drapes, which will not shift out of position if the horse moves, can be useful for certain standing procedures, particularly those performed on the distal limb. When draping is limited or absent, surgeons need to practice "clean" surgery, strictly confining their gloved hands and sterile instruments to the instrument pan or to the properly clipped and scrubbed operative field. Suturing requires special forethought in such circumstances because the long ends of suture material tend to contact nonsterile areas during the act of knot tying.

Proper preparation and draping of an operative field involve a ritual that precludes contamination of the field or the surgeon during the act of draping. Draping creates relative degrees of asepsis from the incision site, where the bacterial count should be the lowest, out to the periphery of the surgical field, where ungowned and ungloved assistants are circulating. After the horse is anesthetized and positioned, a wide area is clipped and, if the surgeon prefers, the incision site is shaved. For a ventral midline laparotomy, we clip and scrub laterally beyond the flank folds and from the pubis rostrally beyond the rib cage and xiphoid cartilage. This allows for maximum extension of the abdominal incision when necessary. For most limb surgery, we clip and scrub the entire circumference of the limb to facilitate the intraoperative palpation of landmarks or the use of multiple approaches (e.g., medial and lateral palmar digital neurectomy).

When handling and positioning drapes, the surgeon's gloved hands are positioned on the side of the drape away from the animal's skin and are "protected" by curling the outer surface of the drape over the hands (see Fig. 3–1*C*). The opened drape must not contact the floor or unprepared areas of the patient. The hands are kept in the central operative field, not peripherally where there would be an increased risk of touching unprepared areas. That portion of the drape that is to be adjacent to the incision site is positioned first and then moved peripherally into the desired location, never the reverse. It is desirable to drape closely, leaving no unnecessary skin exposed. Self-adhering drapes are helpful when larger areas need to be exposed for topographic orientation and palpation. Each succeeding layer of draping builds up the waterproof barrier and covers increasing portions of the field, even the whole horse (see Fig. 3–1*E*).

After draping is complete, final preparations are made for surgery. Suction and cautery lines are passed to circulating assistants, and the autoclaved lamp handle is fastened to the surgery light. It is inappropriate to "reach" beyond the surgical field to affix a lamp handle or make similar preparations before draping is complete. Because draping carries some inherent risk of contamination, some surgeons practice "double gloving" for the act of draping, removing the outer gloves before making the incision. Because equine orthopedic surgery sustains a higher percentage of postoperative infections than most equine soft tissue surgery, we routinely double glove when draping for orthopedic procedures.

Draping materials have changed over the years from semipermeable tight-woven muslin drapes, which were laundered, autoclaved, and reused, to water- and blood-repellent disposable synthetic fabric drapes composed of wood pulp and polyester.[a] Although disposable drapes would appear to be expensive on a single-use basis, they are superior barriers to contamination of the operative field, ensure quality control, and preclude

[a]Sontara, DuPont Co., Wilmington, DE.

the time and labor required to prepare reusable drapes. We use a complete sterile drape set for ventral midline laparotomies that is commercially prepared to our specifications.[b] This set includes four 41 × 58-inch half sheets that are used for quadrant draping, one 77 × 140-inch large fenestrated drape that is used to cover the entire animal, and a polyethylene "poly-U drape" or self-adhering U sheet, which provides protection from bacterial penetration or strike-through when moist bowel is exteriorized for abdominal exploration and intestinal procedures. These six drapes are wrapped in a 44 × 76-inch table cover and is the first pack to be opened when setting up for abdominal surgery.

Figure 3–1 illustrates the positioning and draping of a horse for ventral midline laparotomy. After the horse is anesthetized, it is positioned in dorsal recumbency on a properly padded operating table with the forelimbs partially extended and the hind limbs semiflexed (see Fig. 3–1*A*). The feet, distal limbs, and tail are covered with disposable obstetric sleeves. The ventral abdomen is routinely clipped, shaved, and scrubbed. The first step in sterile draping involves the covering of both hind limbs with hydrogen peroxide gas–sterilized plastic garbage bags (see Fig. 3–1*B*). These bags are handled by the outside surface because gas penetration of the collapsed garbage bag provides inconsistent sterilization of the inside surface, which comes in contact with the hind limbs. Quadrant draping of the incision site with four half sheets is the next step and is performed carefully to preclude peripheral contamination (see Fig. 3–1*C*). Towel clamps are affixed at each corner, and two additional towel clamps are used to hold the lateral quadrant drapes together both rostrally and caudally to the intended incision site. This helps to keep the drapes from shifting and provides extra thickness of drape material immediately peripheral to the operative field (see Fig. 3–1*D*).

The large fenestrated drape is positioned and opened in an "accordion" fashion to cover the entire horse. Because of the size of this drape, it is appropriate for two surgically attired persons to open it to avoid contamination. The excess drape is gathered around each hind limb and held with towel clamps to facilitate the working space (see Fig. 3–1*E*). Unscrubbed assistants use towel clamps to hold the drape in place over the extended forelimbs, providing a sterile shield between the operative field and the anesthetist (see Fig. 3–1*E*). Because bowel resection constitutes clean-contaminated surgery, with risk of contamination of incised body wall tissues, we routinely use a 36 × 36-inch thin plastic wound protector[c] for equine abdominal surgery (see Fig. 3–1*F*). This wound protector comes with an 11-inch flexible ring, which provides suitable access for abdominal exploration and room for bowel exteriorization for virtually all intestinal procedures. After the incision is made and hemostasis is completed, the ring is inserted and expanded just inside the peritoneal cavity, and the plastic sheet is stretched and held in place at the four corners with clamps that secure it to the underlying drapes (see Fig. 3–1*G*). Finally, the polyethylene U drape is applied over the ring drape by removing the protective strips that cover the adhesive area on the underneath surface that surrounds the split (see Fig. 3–1*H*). The impervious central area of the large fenestrated drape, the plastic wound protector, and the split sheet provide excellent protection against strike-through in the wet operative field that accompanies abdominal surgery.

[b]Purdue University colic pack, Maxxim Medical, Inc., Clearwater, FL.

[c]Vi-Drape wound protector, Becton Dickinson Acute Care Division, Franklin Lakes, NJ.



Figure 3–1.

Positioning and draping for ventral midline laparotomy. *A,* Horse properly positioned in dorsal recumbency with forelimbs partially extended and hind limbs semiflexed. *B,* Gas-sterilized garbage bags are used to cover the hind limbs.

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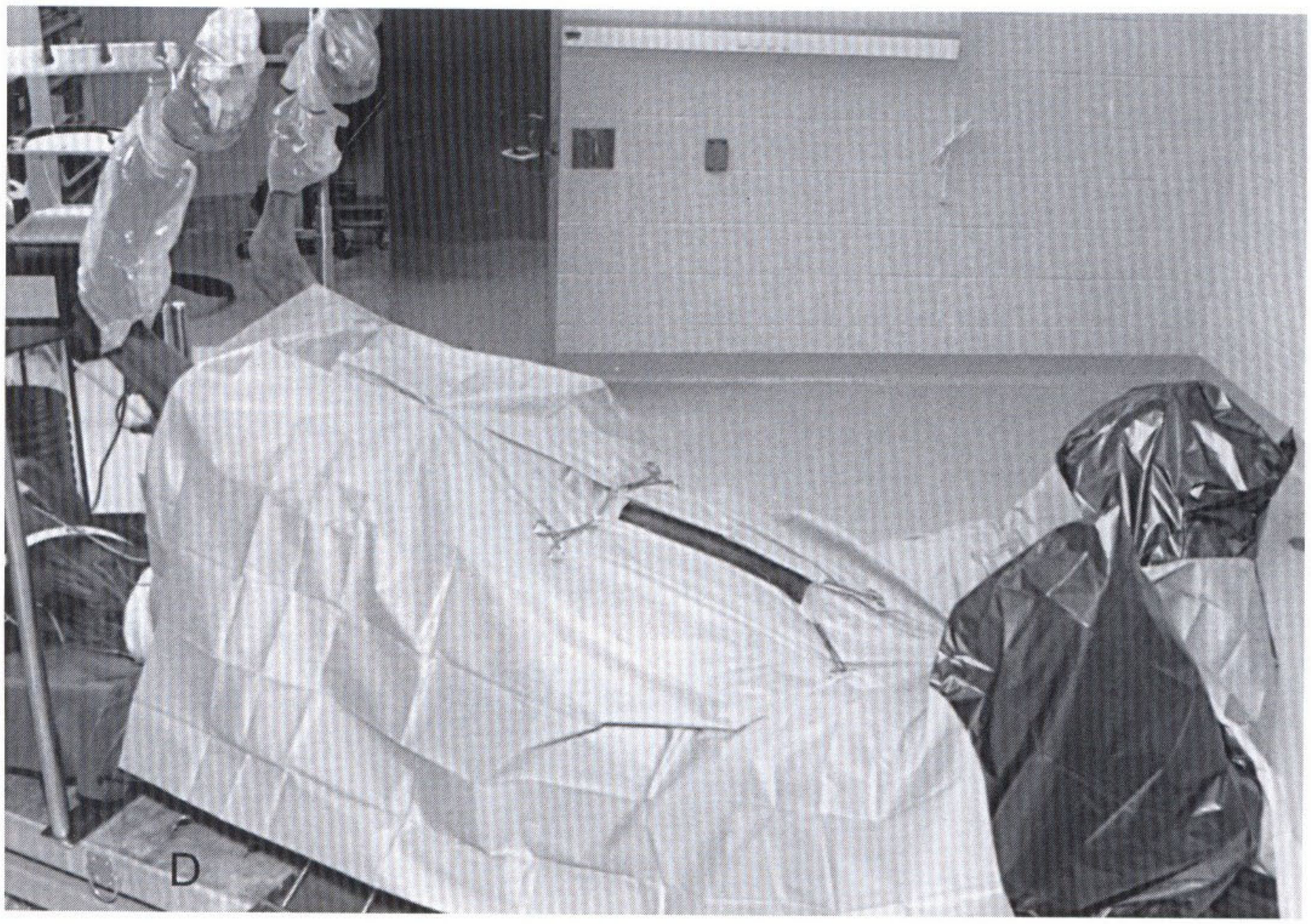


Figure 3–1 *Continued.*

C, Quadrant draping of the incision site. Note how the surgeon's hands are protected by the drape. *D,* The quadrant draping is complete.





Figure 3–1 *Continued.*

E, A large fenestrated drape covers the entire horse. *F,* After incision, a plastic wound protector with a flexible ring is positioned and ready for insertion.

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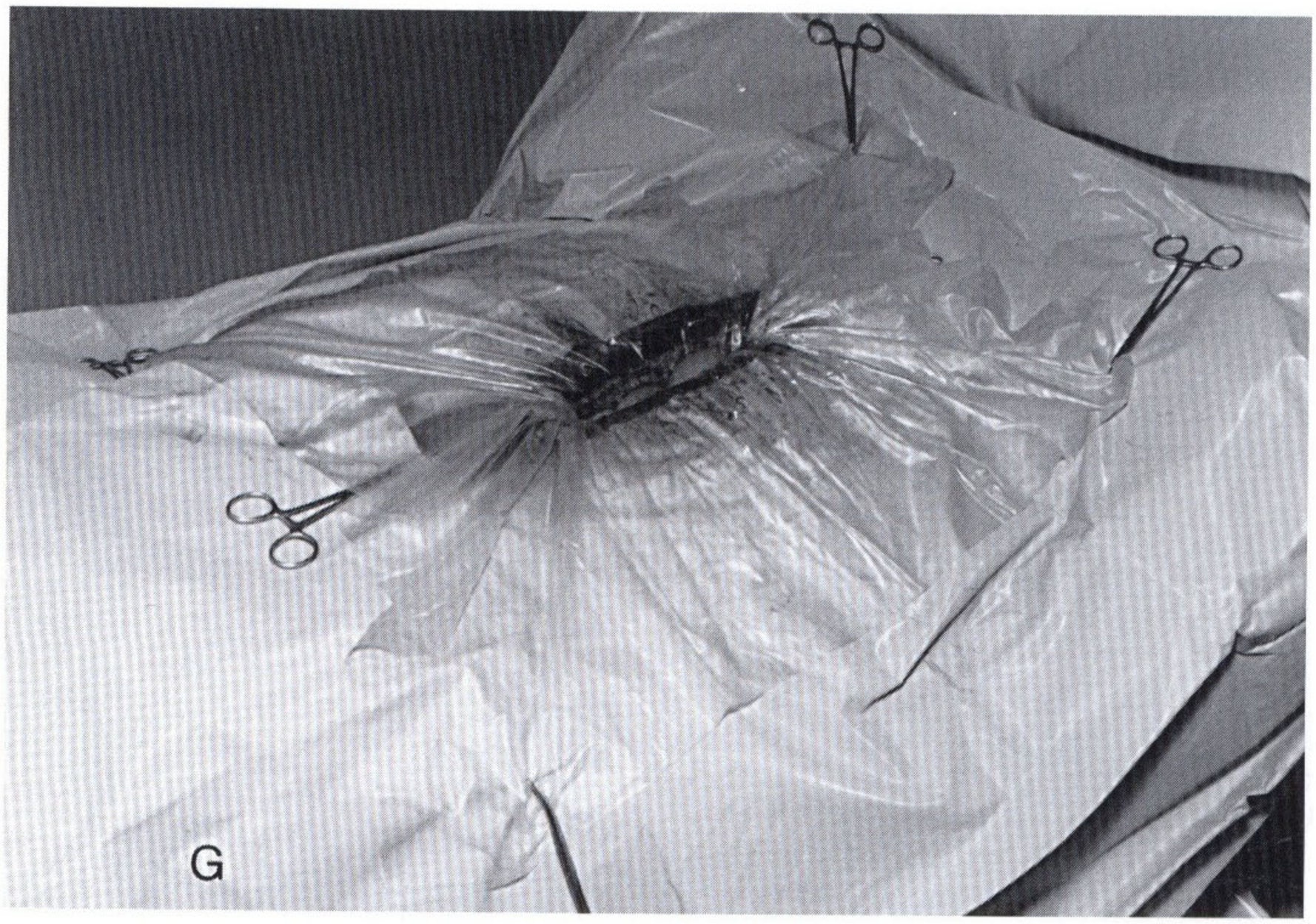




Figure 3–1 *Continued.*

G, The flexible ring is within the abdominal cavity, and the protector is stretched and held in place with clamps at the four corners. *H,* A polyethylene U drape is adhered to the ring drape to provide the final protection against strike-through.

Two different methods for draping the distal extremity are illustrated. The first method (Fig. 3–2) provides access to the entire circumference of the limb and is useful for surgery of the foot and for various orthopedic procedures of the distal limb (e.g., arthrodesis of the proximal interphalangeal joint). The horse is positioned in lateral recumbency with the affected limb suspended and stabilized in the desired position (see Fig. 3–2*A*). When farriery has been neglected or trimming cannot be done on the standing animal, the foot is trimmed as the first step in establishing a carefully controlled aseptic environment for distal limb surgery (see Fig. 3–2*B*). The foot is covered with a rubber glove, which is taped in place to prevent it from slipping off. After the final surgical scrub of the entire circumference of the limb, the skin is allowed to air-dry and is then sprayed with a sterile vinyl chloride copolymer adhesive product[d] (see Fig. 3–2*C*). A 41 × 58-inch half sheet is applied above the intended operative field by encircling the limb and holding the drape in place with a towel clamp (see Fig. 3–2*D*). Next, a self-adhering plastic drape[e] is applied around the entire limb and foot. It is important for the self-adhering drape to be sealed to the half sheet proximally, to cover the entire foot distally, and to adhere to itself on the opposite surface of the limb from the intended incision site (see Fig. 3–2*E*). Excess self-adhering draping can be trimmed away with scissors and discarded. A second half sheet is wrapped around the foot, folded over the sole, and bandaged in place with 4-inch-wide sterile semielastic bandaging tape[f] (see Fig. 3–2*F*). To reiterate, the foot has been trimmed and covered sequentially with a rubber glove, adhesive tape, self-adhering draping, a half sheet, and elastic bandage; the last three layers have been sterile. We believe such attention to the foot is appropriate to preclude potential contamination of the operative field, particularly when orthopedic procedures are planned. The application of an 80 × 119-inch extremity sheet[g] is the final step in draping for full circumferential access to the distal extremity. The extremity sheet has a 6-cm expandable fenestration through which the foot is passed (see Fig. 3–2*G*). The fenestration is snugged about the limb proximal to the incision site and held in place with a towel clamp (see Fig. 3–2*H*). The remainder of the extremity sheet is opened accordion style to cover most of the horse. The operative site is now ready for surgery.

[d]Vi-Drape adhesive, Becton Dickinson AcuteCare Division, Franklin Lakes, NJ.

[e]Ioban 2 antimicrobial film, Animal Care Products, 3M Health Care, St. Paul, MN.

[f]Vetrap, Animal Care Products, 3M Health Care, St. Paul, MN.

[g]Barrier extremity sheet, Johnson & Johnson Medical Inc., Arlington, TX.



Figure 3–2.

Positioning and draping for access to the entire circumference of a limb. *A,* Horse positioned in lateral recumbency for surgery of the left forelimb. Note that the up limbs are supported in stirrups.

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Figure 3–2 *Continued.*

B, Foot trimming is an essential step when preparing for distal limb surgery. *C*, After the foot has been covered and the limb routinely scrubbed, a sterile adhesive is sprayed on the limb to aid the application of a self-adhering drape.

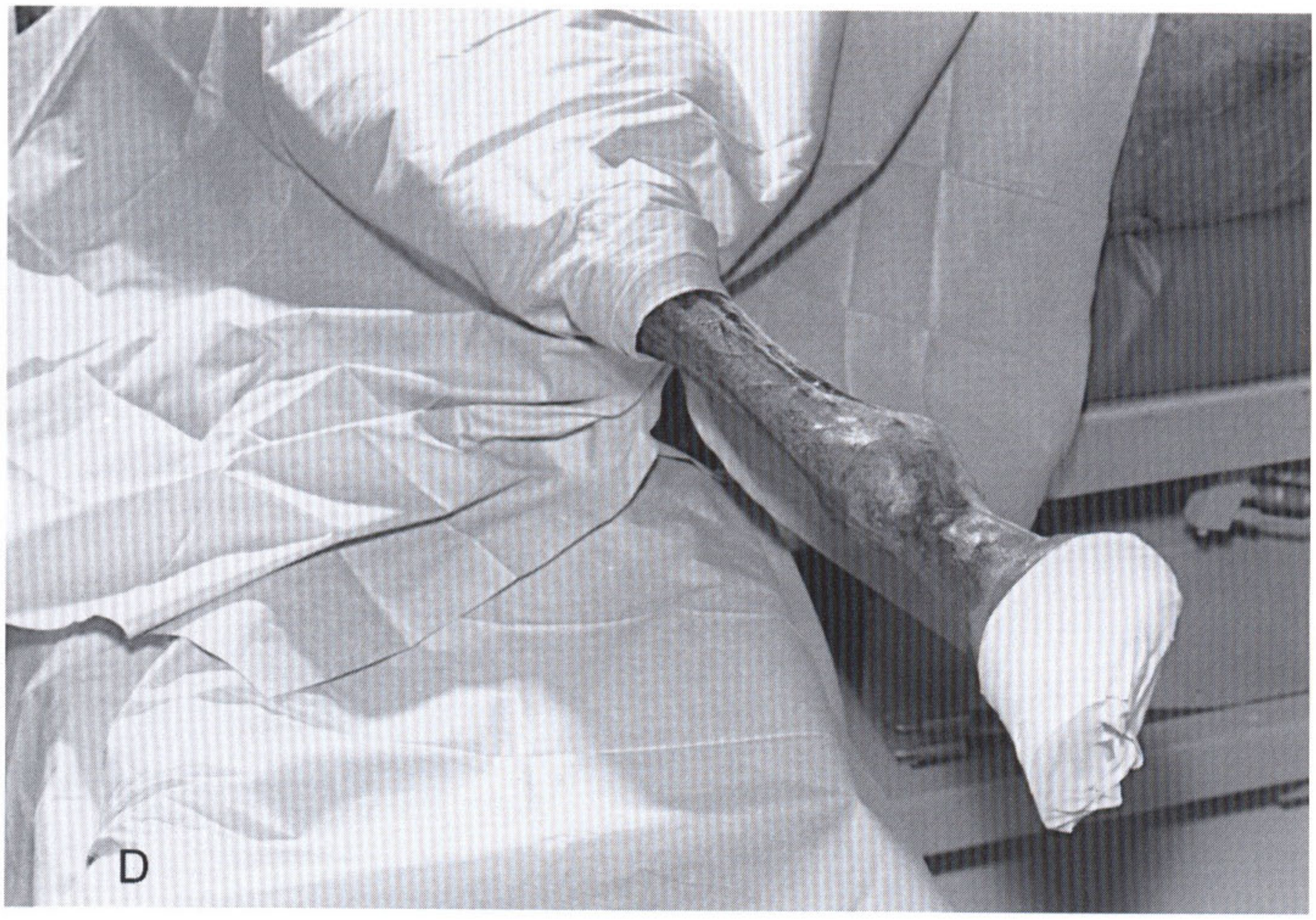




Figure 3–2 *Continued.*

D, A half sheet is applied about the operative field and held in place with a towel clamp. *E,* The self-adhering drape is sealed to the half sheet proximally and covers the entire distal limb and foot.

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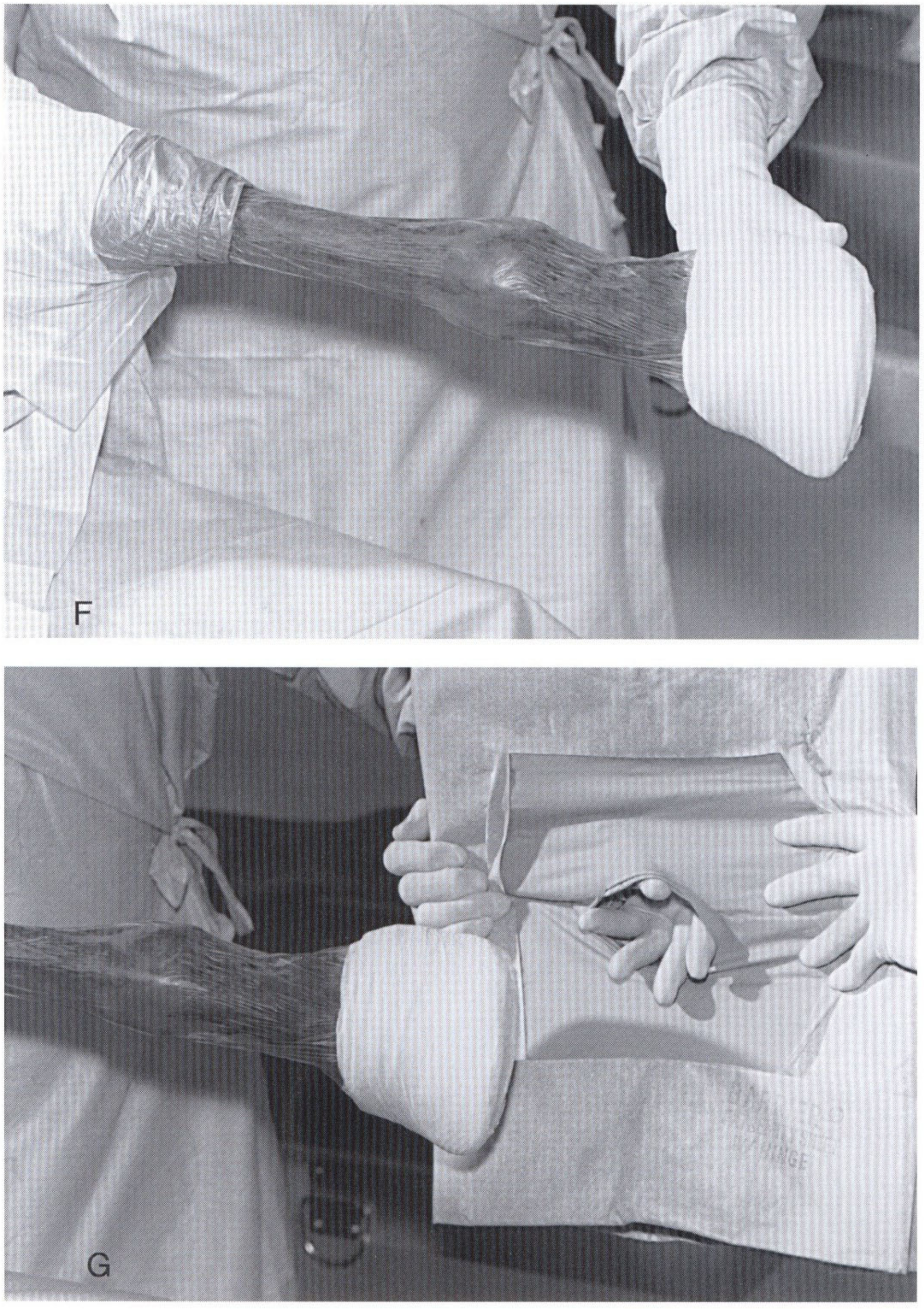


Figure 3–2 *Continued.*

F, A second half sheet is wrapped around the foot, folded over the sole, and bandaged in place with sterile tape. *G,* An extremity sheet with a 6-cm expandable fenestration is passed over the foot.

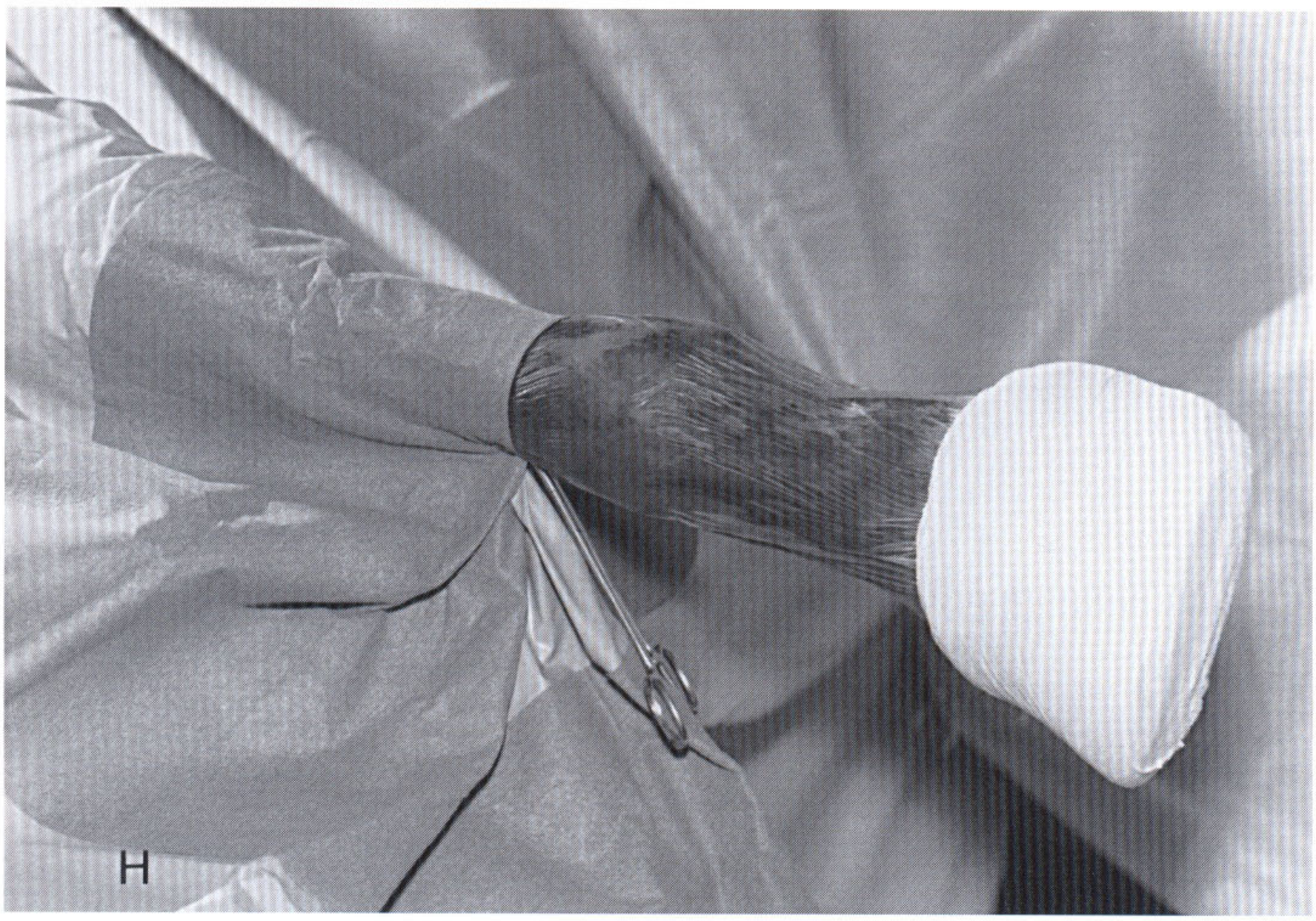


Figure 3–2 *Continued.*

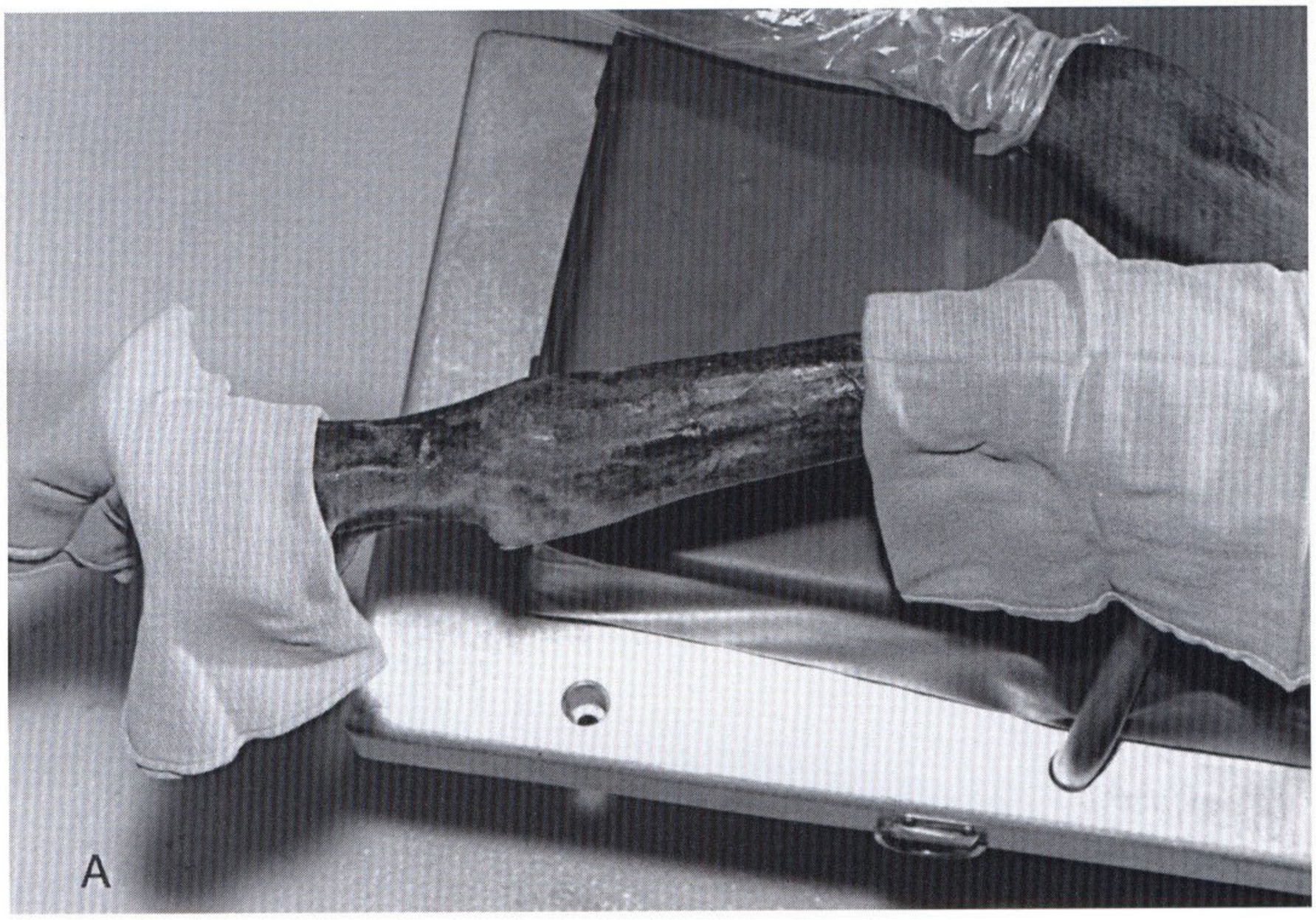
H, The fenestration is snugged about the limb proximal to the incision site and clamped in place.

The other method for draping the distal extremity constitutes a quadrant-draping approach and is used for procedures such as fetlock arthrotomy, distal check desmotomy, and fractured splint bone resection (Fig. 3–3). The first step is to cover the foot and proximal limb with sterile hand towels (see Fig. 3–3*A*), providing additional barriers to contamination. Half sheets are applied as quadrant drapes, with the longitudinal sheets pulled together over the foot and proximal limb and held in place with the fifth and sixth towel clamps (see Fig. 3–3*B*). A self-adhering drape is applied over the quadrant drapes, providing additional waterproofing and helping to hold drapes and towel clamps in position (see Fig. 3–3*C*). Finally, the entire horse and limb are covered with a 138 × 160-inch nonfenestrated drape.[h] Scissors are used to cut an appropriately sized fenestration at the incision site, the cut edges are rolled under, and the fenestration is held in place with two towel clamps (see Fig. 3–3*D*). The limb is now prepared for surgery.

When horses are positioned in dorsal recumbency with one or both limbs extended, draping is a modification of the first method, which provides access to the entire circumference of the limb. Because the hoof is above the operative field, special care is taken to cover the foot and the suspension apparatus. Sterile hand towels or half sheets are used to wrap this area, and the surgeon is double gloved, at least for this portion of the draping. Another half sheet encircles the limb proximal (below) the intended operative field, and a self-adhering plastic drape is applied around the entire limb. The self-adhering drape is sealed to the foot cover above and to the half sheet below. Additional drapes are required if the remainder of the horse is to be covered. Intraoperatively, the surgeon is careful to not touch those portions of the leg suspension apparatus that cannot be completely covered.

These draping methods and materials are cost-effective in our practice, where a team approach is used for all major surgery and optimal patient protection is desired. The draping methods can be used as described or can be modified to fit most surgical practice situations with confidence that the patient is being provided the level of protection that is warranted.

[h]Equine drape, Maxxim Medical, Inc., Clearwater, FL.



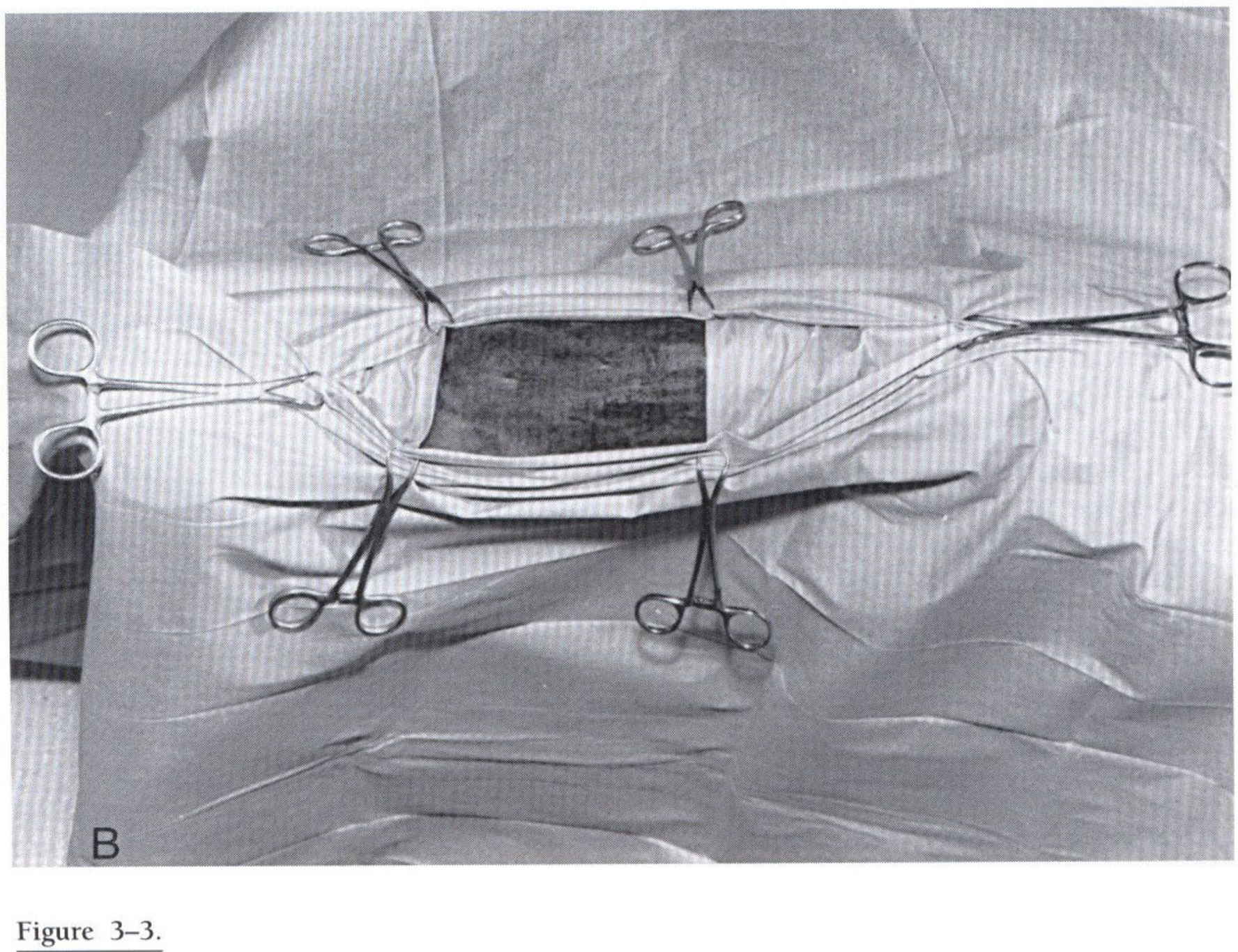


Figure 3–3.

Quadrant draping for limited intraoperative access to a limb. *A,* Hand towels cover the foot and proximal limb. *B,* Quadrant draping in place with the longitudinal sheets pulled together over the foot and proximal limb and held in place with two additional towel clamps.



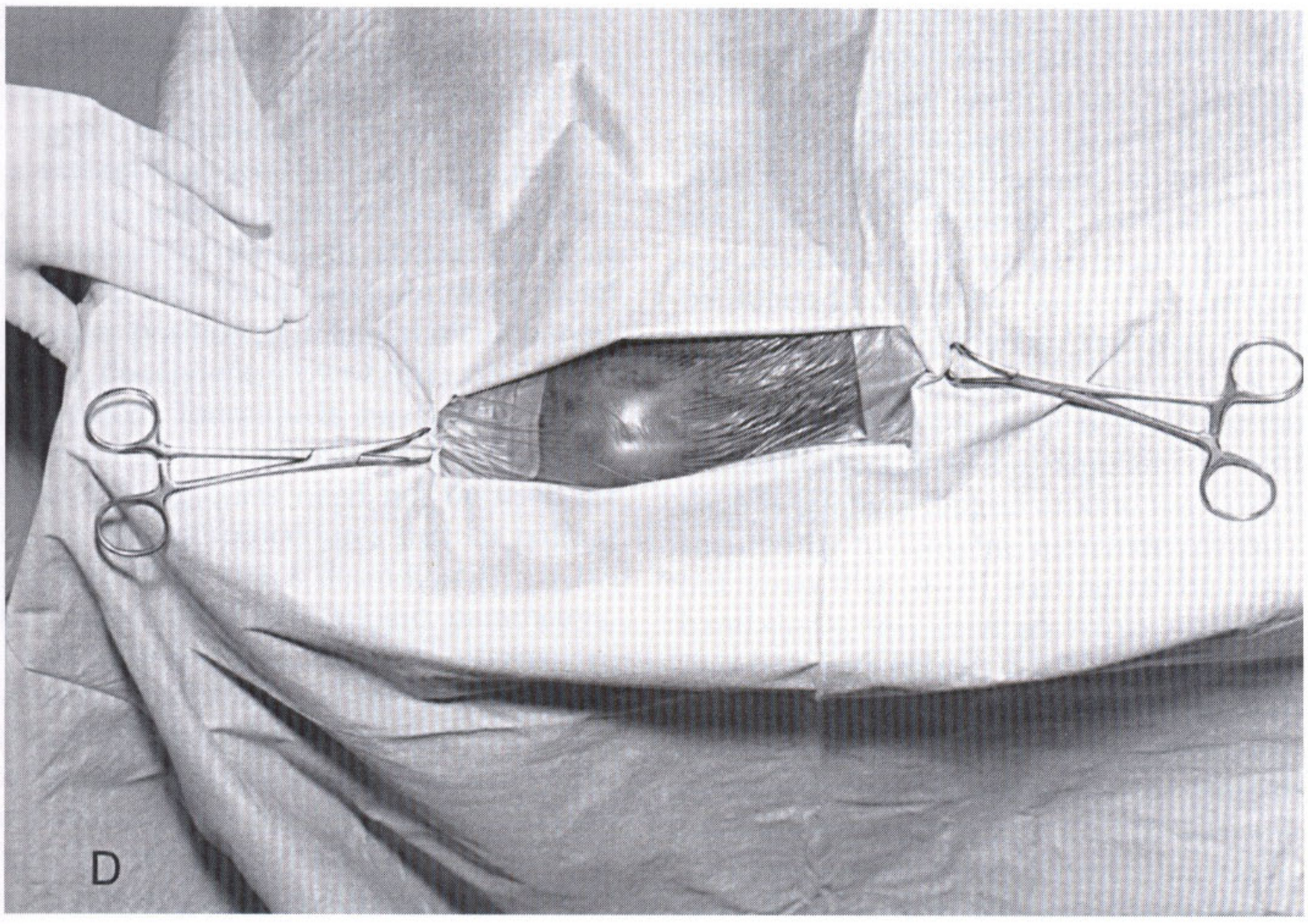


Figure 3–3 *Continued.*

C, A self-adhering drape is applied over the quadrant drapes. *D,* A nonfenestrated drape is used to cover the entire horse. A fenestration is cut with scissors at the incision site, the cut edges are rolled under, and the fenestration is held in place with towel clamps.

chapter 4

Tourniquets

The application of a tourniquet is not a benign procedure.
BLASS, MOORE

Application of a tourniquet around an extremity compresses the blood vessels. The tourniquet prevents circulation distal to the level of application and controls hemorrhage. Tourniquets decrease blood loss during surgery and allow the surgeon to examine structures clearly and operate more quickly.[1] Tourniquets are most often used on horses for orthopedic surgery distal to the carpus and tarsus. Some surgeons use them regularly, and others seldom use them. The position of the limb during surgery often determines whether a tourniquet is needed. Tourniquets are rarely needed when horses are positioned in dorsal recumbency and the limb to be operated on is extended above the horse. Natural venous drainage and the lower peripheral blood pressure created by the position of the limb above the heart markedly reduce bleeding. Tourniquets are more useful on the limbs of horses positioned in lateral recumbency, particularly for the dependent (down) limb and when bleeding is anticipated. Tourniquets have been advocated for the control of hemorrhage for hoof surgery in standing horses.[2] Tourniquets need not be used for relatively bloodless surgical procedures such as palmar digital neurectomy or distal check desmotomy.

Tourniquets alter many physiologic parameters, both locally and systemically. The alterations are caused by ischemia, pressure, and pain. Tourniquet application to the distal extremity of horses for 2 hours causes local acidemia, increased serum potassium concentrations, and reduction of the hematocrit values in the vein of the affected limb.[3] All values return to normal within 15 minutes of tourniquet release. Blood flow in the limb to which a tourniquet has been applied returns to normal within 10 minutes after removal. Tourniquet placement on the distal limbs of anesthetized horses may cause systemic hypertension.[4, 5] The hypertension is more pronounced when the tourniquet is placed on the dependent limb. Deflation of the tourniquet causes an immediate decrease in the elevated systemic blood pressure.[5] This response to the tourniquet may make monitoring of the depth of general anesthesia in horses difficult. Tourniquets have been associated with neuropathies, nerve palsy, necrotic muscle damage, and limb edema in both dogs and humans.[6] However, horses rarely have peripheral neuropathy or muscle damage after tourniquet application. This is because most tourniquet applications in horses are on the distal limb below muscle bellies.

The Esmarch bandage[a] is inexpensive and is often used as a tourniquet for limb surgery. The Esmarch bandage is made from rubber and is 4 inches wide and 4 yards long. When properly applied, the bandage exsanguinates blood from the superficial vasculature of the limb and prevents hemorrhage by compression of vessels. The bandage is effective when placed above or below the carpus or tarsus. However, when surgery is performed on the lower limb, the bandage should stop just below the carpus or tarsus. The Esmarch bandage is applied by starting a tight, uniformly stretched wrap over the hoof capsule and wrapping up the limb. The starting end of the bandage is left uncovered so it may be pulled free after the wrap is secured proximally. The bandage is overlapped by one half of its width as it is unrolled. This procedure exsanguinates the blood from the limb. At the proximal position on the limb, where the tourniquet is to be maintained, the Esmarch bandage is tightly wrapped around the limb four times and secured by tucking the remainder of the roll under the last wrap (Fig. 4–1). Starting at the foot, the Esmarch bandage is now unwrapped up to the proximal level. This bandage creates a relatively bloodless surgery site in the distal limb. The duration of application for Esmarch tourniquets for safe use has not been clearly established in horses. Ischemic periods after application of a tourniquet for up to 3 hours result in minimal clinical abnormalities in other species.[6] Clinical experience suggests that Esmarch bandages on horses are safe for at least 2 hours of application unless systemic hypertension develops.

The pneumatic cuff applies uniform pressure to a relatively wide area and is less likely to cause local tissue damage than an Esmarch bandage. Pneumatic tourniquets that use dichlorodifluoromethane for cuff inflation are commercially available.[b] The pneumatic

[a]Esmarch bandage, American Hospital Company, McGaw Park, IL.

[b]Pneumatic tourniquet, Walter Kidde, Mebane, NC.



Figure 4–1.

The Esmarch bandage is tightly rolled up the limb by overlapping one half the width of the bandage to exsanguinate venous blood. At the proximal level of the metacarpus, the bandage is rolled around the limb four times and secured by tucking the remaining roll under the last wrap. The bandage is next unrolled from the foot to the proximal level and left in place as a tourniquet.

cuff may be placed at any level on the equine limb, but the gastrocnemius tendon should be avoided. Pneumatic tourniquets are more expensive than Esmarch bandages and are not used as often in equine practice. The pneumatic tourniquet is applied by wrapping the pneumatic cuff around the limb at the desired location and attaching the cuff to the inflation device (Fig. 4–2). The cuff is then pressurized to effect hemostasis. The pressure can be adjusted within a wide range but should not exceed 300 mm Hg.[3] The inflation pressure should be the minimum necessary to stop bleeding. This pressure is generally about 100 mm Hg above systolic blood pressure.[6] The duration of use in horses is largely empiric. We recommend 2 hours of ischemia as the maximum duration in horses. However, if longer surgical times or higher cuff pressure is needed, the pneumatic cuff can be deflated for 5 minutes and then reinflated. This may decrease the risk of ischemic injury to tissues. The tourniquet should be released immediately if systemic hypertension develops. The pneumatic tourniquet may be used to maintain hemostasis after application of an Esmarch bandage to exsanguinate the blood from the limb. Exsanguination of blood can also be accomplished before application of a pneumatic cuff by elevating the limb above the heart for 5 minutes.

Tourniquets are a useful adjunct to orthopedic surgery in horses. They are particularly useful for distal limb and hoof surgery to control hemorrhage and to aid visualization of the surgical field. When properly used, tourniquets should decrease surgical time. Tourniquets should not be used as a substitute for proper surgical hemostasis. Incisional bleeding in the postoperative period may contribute to wound complications. Severed open lumen vessels with diameters of 1 mm or larger

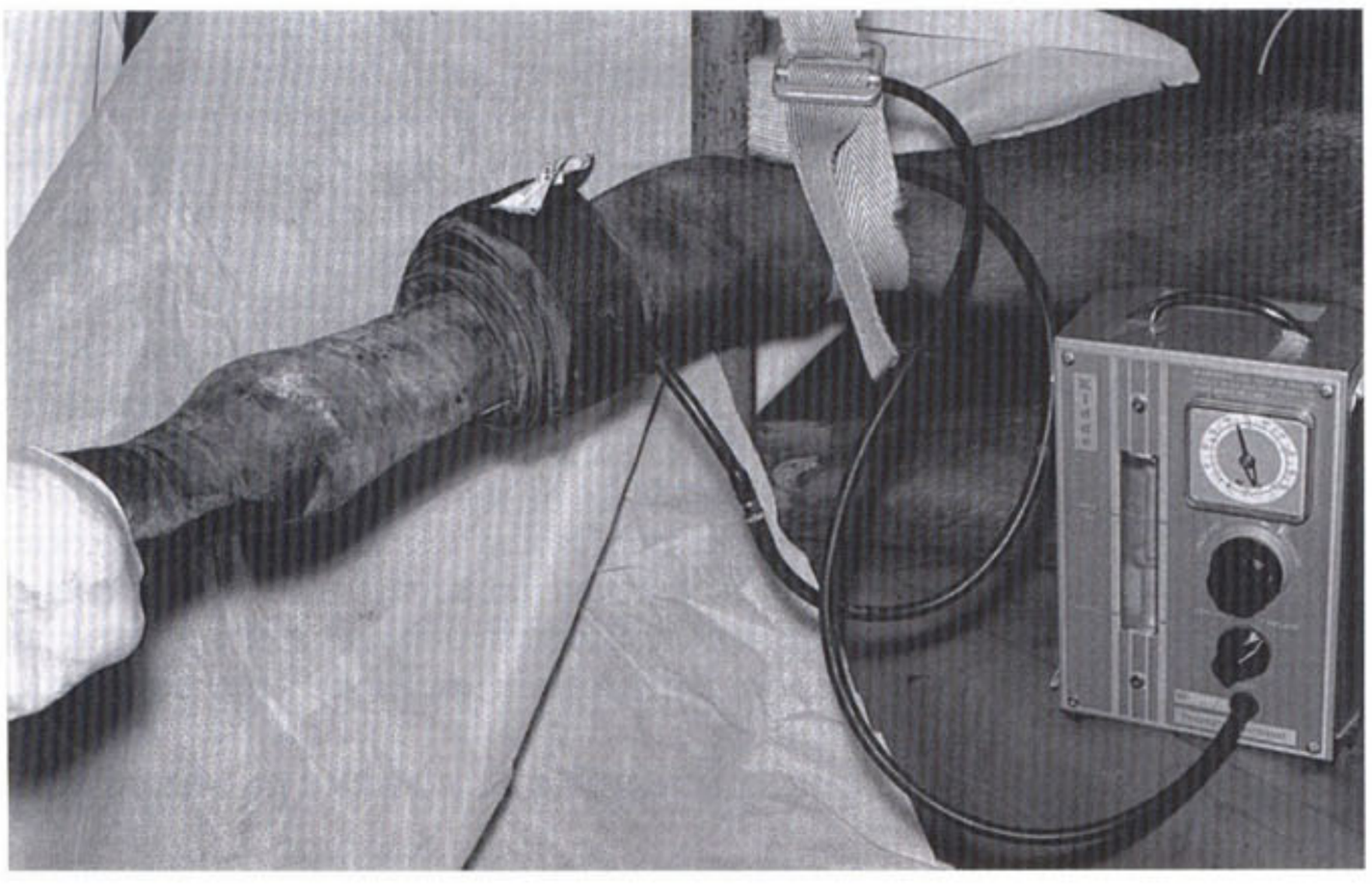


Figure 4–2.

Placement of a pneumatic tourniquet on the lower limb of a horse.

should be occluded by hemostat application, electrocautery, or ligation. Such vessels are usually visible, even in an exsanguinated field. Otherwise, these vessels will bleed once the tourniquet is released. Proper attention to open lumen vessels should allow the complication rate of surgical wounds created during tourniquet application to be no greater than the rate for wounds created when tourniquets are not used. Some surgeons prefer to release tourniquets before wound closure to check for and control hemorrhage. This can be helpful for foot surgery and for horses in which the limb will be cast after surgery. Other surgeons believe surgical sites on distal limbs should be bandaged before tourniquet release to reduce postoperative hemorrhage and edema.[7]

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chapter 5

Suturing

The first intention of a suture is to heal by first intention. *The faults in making sutures are the manufacturer's, the errors in using them are the surgeon's.*

SNYDER

History is replete with evidence of suturing as a surgical procedure. Egyptian mummies with sutured wounds have been exhumed. The Edwin Smith Surgical Papyrus, recognized as the oldest known surgical text, describes 48 surgical cases 4000 years ago and documents wounds, stitches, and stitching. One thousand years later, ants were enticed to bite tissues and were then decapitated, leaving the head and pinchers to approximate wound margins. By 2500 years ago, braided horsehair, leather strips, cotton fibers, animal sinews, and bark had all been used. Cotton and animal sinews (i.e., catgut) have survived as suture material to the present day.

Contemporary history in veterinary medicine, the last 30 to 40 years, records changes from the use of catgut, which is absorbed by inflammation, to the use of glycolic acid derivatives, which are absorbed by hydrolysis, to the current use of hydrocarbon polymer derivatives, which are delayed-absorbable by slow hydrolysis or are nonabsorbable (Table 5–1). The monofilament synthetic suture materials create minimal foreign body response in the tissues and provide suitable strength and, with conscientious practice, suitable handling. Although they are slightly more expensive than traditional suture materials, their advantages far outweigh the increased costs. The days of catgut and silk are over in equine surgery. We have turned to the monofilament synthetics, polydioxanone and polypropylene, for virtually all of the surgical applications described in this atlas.

Suture manufacturing companies provide suture use manuals that describe the available materials, the do's and don'ts of suture use, and their general applications. The characteristics of commonly used suture materials in veterinary surgery, including absorption, body reaction, strength, and knot security, are listed in Table 5–1. In the past, surgeons have chosen suture materials based on habit, guesswork, and the physical characteristics of the material itself. Handling ability and knot tying have been important. For decades, silk was commonly used in human surgery, presumably because of its excellent handling properties, even though it was associated with a rapid loss of strength and a high infection rate. Traditionally, surgeons have selected sutures based on what they were taught. However, suture materials, and to some extent suture patterns, should be selected on the basis of the wound itself and the biologic interaction between the suture and the tissue. With patience and practice, surgeons can learn proper handling and knot tying for the material in question, proceeding with confidence in their skills and knowing that the most compatible material has been selected. Suturing and knot tying require manipulative skill and, more importantly, practice. It is wrong to select and use an incompatible material that is comfortable or familiar to the surgeon's hands rather than practicing, as necessary, with the appropriate material. Suture placement and knot tying require practice, but they should not become "mechanical." The surgeon must handle and tie each material based on its unique characteristics rather than handling different materials in the same way.

Knot security is necessary for effective suturing. Yet virtually all knots slip. Additionally, the larger the suture material, the greater is the tendency for slippage. A poorly tied knot with sizes 2–0 or 3–0 material is more secure than a poorly tied knot with size 1 or 2 material. These latter sizes are routinely used in the equine linea alba. A completed knot must be firm to minimize slipping and small to prevent excessive tissue reaction. The cut ends, or "whiskers," should be no longer than necessary to prevent unraveling. We cut 2–0 and 3–0 polydioxanone and similar monofilament suture knots with 1-mm ends but leave slightly longer tails on braided sutures, such as polyglactin 910 or polyglycolic acid, which have poor knot security and a tendency to untie. Large polyester sutures can untie spontaneously during surgery when the tails are cut next to the knot. Sawing or friction between the strands must be avoided, particularly when knotting twisted or braided materials, because it weakens the integrity of the suture. Coated suture materials sustain less friction when being tied, but the coating material decreases knot security and the knotting process itself shreds the coating material, nullifying its value. The shredded coating material and exposed twist or braid may be more detrimental than if a noncoated or monofilament material had been chosen.

Table 5–1.

Characteristics of Commonly Used Suture Materials

Generic Name	Trade Name	Source	Loss of Tensile Strength	Complete Absorption	Mode of Degradation	Foreign Body Response	Number of Throws for Good Knot Security*	Size-Strength Ratio
Absorbable								
Polyglactin 910	Vicryl[a]	Glycolic-lactic acid polymer	35% in 14 days 60% in 21 days	60–70 days	Hydrolysis	Slight	5	Good to excellent
Polyglycolic acid (noncoated)	Dexon[b]	Glycolic acid	35% in 14 days 65% in 21 days	120 days	Hydrolysis	Slight	3	Good
Polydioxanone	PDS II[a]	Polydioxanone polymer	15% in 14 days 30% in 21 days	180 days	Hydrolysis	Slight	4	
Polyglyconate	Maxon[b]	Polytrimethylene carbonate	30% in 14 days 45% in 21 days	180 days	Hydrolysis	Slight	4	
Nonabsorbable								
Stainless steel	—	Chromium nickel molybdenum	NA	NA	NA	Inert	2	Excellent
Polyester	Mersilene[a]	Synthetic resin polymers (extruded)	NA	NA	NA	Moderate	5	Excellent
Nylon	Ethilon[a]	Polyamide filament (extruded)	30% in 2 years	NA	Chemical degradation	Minimal	4	Good
Polypropylene	Prolene[a]	Polymerized polyolefin hydrocarbons (extruded)	NA	NA	NA	Minimal	3	Fair to good

*An additional throw is recommended for continuous patterns.
NA, not applicable.
[a]Ethicon, Inc., Somerville, NJ.
[b]Davis & Geck, Inc., American Cyanamid Co., Manati, PR.

The number of throws necessary to secure square knot with various suture materials has been studied.[1–3] When using sizes 0, 2–0, or 3–0 coated polyglycolic acid sutures, knot security was achieved with one less throw (four throws) than with similar sizes of coated polyglactin 910 sutures (five throws).[1] The knotting and handling characteristics of the coated polyglycolic acid sutures were judged to be superior to those of the coated polyglactin 910 sutures. Also, it was determined that knot security could be achieved with only two throws of noncoated polyglycolic acid sutures. Thus, a reduction in the amount of buried suture material and a reduction in operative time can be achieved by selecting this noncoated material. In another study, a secure knot with size 2–0 suture material was defined as a knot that, when tested to failure, broke rather than untied by slipping.[2] The minimum number of throws necessary to make a secure, snug square knot was determined to be three for catgut, polyglycolic acid, polyglactin 910, and polypropylene. When using polydioxanone or nylon, four throws were necessary. In this study, no loosely tied, asymmetric square knots were as secure as snug square knots.[2]

A report on the use of size 1 or 2 absorbable suture materials (polyglycolic acid, polyglactin 910, polydioxanone), when used to close ventral midline abdominal incisions in horses with a continuous suture pattern, recommended that at least five to six throws be used to secure the knots.[3] The safe anchoring of a continuous suture in the linea alba of the horse is paramount to avoiding knot slippage and the disaster of wound dehiscence. When using size 1 or 2 suture materials, we routinely place four throws for interrupted sutures, but anchor the knots of continuous patterns with five throws. It is important to tie a flat, even square knot, particularly when using the monofilament synthetic materials that have plastic-like memory. As the third and fourth throws are placed, they need to be deliberately set or tightened in a way that elongates the material and locks it into the previous throw. It is like "melting" the throws together. The monofilament materials have the property of elongation, which can be used to advantage to secure the knot without fear of tissue strangulation, but three, four, or five throws are necessary, depending on the size of the material and the suture pattern. Unnecessary extra throws that are poorly placed do not improve knot security with these materials. Such extra throws become an invitation to infection.

Clinical experience in veterinary surgery has led to increasing use of monofilament synthetic materials for buried sutures, particularly the delayed-absorbable suture materials polydioxanone and polyglyconate. They may be used in place of surgical gut, polyglycolic acid, or polyglactin 910 sutures.[4] Polydioxanone or polyglyconate materials are less irritating than surgical gut, last longer than the braided synthetic absorbable and have excellent strength for their comparative size. Sutures should be as strong as normal tissue, but no larger than absolutely necessary. With the exception of nylon, the monofilament synthetics are much stronger and have less tissue drag and better knot security when properly tied than comparable sizes of other materials. They are nonallergenic and nonpyrogenic and have minimal association with infection (see Table 5–1).

Incisions must be closed securely. When a plastic material is used, the tissue can be apposed tightly because the material can yield as tissues swell. The monofilament synthetics have the physical property of irreversible elongation; they remain stretched when the load is withdrawn.[5, 6] For unyielding materials such as stainless steel, loose apposition of incisions is necessary. Surgeons must correctly vary their suturing technique according to the properties of the suture material.

Polydioxanone and polyglyconate have comparable strengths and tissue reactivities (see Table 5–1). However, we believe that polyglyconate has poorer physical properties that make it more difficult to handle. In comparable sizes, polyglyconate is a finer caliber and lighter color than polydioxanone, making it harder to see in the surgical field, particularly when blue-gray drapes are used. Both products tend to curl, especially when stretched, but polyglyconate has more memory and tends to kink worse in our hands. The knot security of polyglyconate is unreliable in the hands of novice surgeons; our veterinary students have experienced wound disruptions in their surgical laboratory animals. Last, polyglyconate is not manufactured with an appropriate needle selection for equine surgery and is not available in size 2.

The tissues being sutured should be altered as little as possible by the needle. The needle should make a hole in the tissue only large enough to permit passage of the suture material. The common practice of double-threading eyed needles, to keep the strand threaded, tears a large hole in tissues and should be avoided. Swagged-on needles are recommended for all applications in equine surgery. When tissue density allows, a taper-point needle is used. When a taper-point needle will not penetrate the tissues, some type of cutting needle is required. Because of the dense, thick nature of the equine linea alba, we routinely use a swagged-on reverse cutting needle when suturing this structure. The reverse cutting needle combines a cutting point with a round needle shaft, leaving a hole in the tissues that approximates the size of the suture material. Reverse cutting needles are used to suture the dermis or epidermis.

It is well known in human surgery that the incidence of wound infection and suture sinus formation, in both clean and contaminated wounds, is less with monofilament synthetic materials than with surgical gut or any of the braided or twisted materials. If a wound

closed with a braided material becomes infected, there is an 80% chance that one or more suture sinuses will form.[7] The incidence of sinus formation with monofilament materials is less than 10%. This problem with braided materials has been documented for horses after laparotomy.[8] The presence of foreign material and the physical and chemical properties of the suture material account, in part, for this predisposition to infection.[9–12] One million pathogenic microorganisms per gram of tissue are required to elicit pus-forming clinical infection in otherwise healthy tissue. Under identical conditions, inclusion of a single braided silk suture reduces the pus-forming dose to a mere 100 microorganisms per gram of tissue.[7] Braided and twisted materials have more drag as they pass through the tissues.[10, 11] Microorganisms can be trapped in the interstices of the braid or twist or within the throws of the suture knot. Suture sinus formation has followed the use of size 2 monofilament synthetic material in the horse with buried tension-type suture patterns.[12] Size 2 materials create bulky knots, particularly when five or six throws are used. These knots may contribute to suture sinus formation but are necessary for knot security.

Nylon and polyglycolic acid are believed to have degradation products that are potent antibacterial agents.[9] Experimentally, the infection rate in contaminated tissues after the use of polyglycolic acid is significantly lower than that in contaminated tissues containing surgical gut.[9] Similarly, the infection rate with braided nylon is lower than that with other multifilament nonabsorbable suture materials.[9] Occasionally, veterinary surgeons are faced with the need to use buried sutures in infected tissue. The monofilament synthetic materials are the best choice in such circumstances, and if a nonabsorbable material is needed, nylon can be used with the expectation that problems related to the suture per se will be minimal. Also, monofilament stainless steel is tolerated well by infected tissues. Stainless steel skin staples are a good choice for skin apposition in circumstances involving heavily contaminated or infected tissues.[13]

Skin sutures may delay healing by prolonging or increasing the inflammatory reaction beyond the immediate postoperative period. This can occur by leaving skin sutures in too long. There is a tendency for veterinarians to leave skin sutures in place longer than necessary. Commonly, large-animal surgery texts recommend stitch removal between 10 and 14 days. If the subcutaneous tissues and dermis have been properly apposed and healing has been uninterrupted, sutures in the epidermis can be removed by day 7 or 8, sometimes earlier, and certainly no later than day 10. When large, irritating, full-thickness skin sutures are left in place for unnecessarily long periods, epithelial cells migrate along the suture tracts into the subcutaneous tissues. The resultant keratin produces a subcutaneous foreign body reaction. These so-called stitch abscesses, easily confused with infection, cause the permanent, unsightly stitch scar. Similarly, when faced with true wound infection, as evidenced by excessive swelling, tenderness, and discharge, inexperienced surgeons leave skin sutures in place longer than desirable under the misguided premise that such a wound needs suture support for eventual healing. Rather, wound discharge is a clear sign of infection and signals a lost opportunity for primary healing. Sutures should be removed to facilitate drainage from the segment of wound involved, which will lead to earlier resolution and healing than if sutures are left in place.

Tension sutures (with the use of buttons, tubing, or gauze as bolsters) and stents are used occasionally in equine surgery. Repair of wounds in areas of the body with limited skin elasticity and increased tension (i.e., below the carpus and tarsus) may be aided by tension sutures. Stents are beneficial when there are contour irregularities and when the wound cannot be bandaged or would be otherwise exposed to trauma. Wounds of the upper limbs and trunk lend themselves to stent bandages or tie-over packs. Tension sutures and stent bandages can be helpful provided that three important principles are kept in mind: (1) dermal circulation must not be compromised, (2) they should not be the sole means of apposing and supporting the tissues, and (3) they should be removed as soon as possible, usually by 72 hours after surgery. A vertical mattress pattern is preferable to a horizontal mattress pattern for bolstered tension sutures. Dermal circulation to the skin wound margins should be compromised less when the tension is perpendicular to the incision. Because stent bandages are used in areas of the body that cannot be conventionally bandaged, their purpose is to relieve tension on the primary sutures and to counteract the initial edema and swelling that follow surgery. This initial period of tension and swelling resolves by day 3 in wounds that are healing primarily. Leaving a stent bandage in place longer increases the probability of skin festering at the stent suture sites.

In conclusion, the characteristics of a perfect suture material include good handling quality, good knot security, adequate tensile strength, lack of allergenic properties, minimal tissue reaction, and no adverse effect on a wound in the presence of infection. In the future, tissue adhesives and products resulting from molecular biology will take suturing to new thresholds. For now, the concept of an ideal suture is probably a myth. Technique has a human element. The surgeon selects the material. The surgeon selects the pattern. The surgeon uses small bites, large bites, or just-right bites that are too loose, too tight, or just right. The proper handling of tissues during surgery and suturing is important, probably more important than material or pattern. In that respect, the art of surgery remains center stage.

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chapter 6

Prophylactic Antibiotics

Antibiotics will turn a third class surgeon into a second class surgeon, but they will never turn a second class surgeon into a first class surgeon.

ANONYMOUS

Antimicrobial prophylaxis is defined as the administration of antibiotics to a patient in the absence of infection. It is anticipatory therapy in terms of potential tissue contamination. To be effective, the antimicrobial drugs must supplement normal host defenses. As such, they must be present in normal tissues that are free of inflammation when bacterial contamination occurs.[1] Antibiotics are unquestionably effective in helping to prevent postoperative wound infection, but there is still much to be learned about the optimal drug choice, dose, timing, duration, and cost-effectiveness of antibiotic prophylaxis, particularly in the horse.

The total number of contaminating bacteria, as well as their virulence, is important in determining the prevalence of postoperative wound infection, but these factors cannot be known beforehand. In addition to the degree of contamination, tissue viability is the primary factor that determines whether a surgical wound will become infected. For clean surgical procedures, contamination and tissue viability can be controlled by the surgeon. The surgeon's technical skill is the most important factor in creating a wound that is inhospitable to bacteria. Antibiotics cannot compensate for the lack of hemostasis, for the presence of dead space leading to seroma formation, for excessively devitalized tissue, or for excessive foreign materials left in the wound.

An understanding of the classification of surgical wounds is important when considering appropriate antimicrobial prophylaxis. Surgical wounds are classified as clean, clean-contaminated, contaminated, and dirty or infected. *Clean wounds* result from incisions made under aseptic conditions. Except for the ever-present deep-seated organisms in the dermis, no contamination occurs. A ventral midline laparotomy with abdominal exploration is an example of clean surgery in the horse.

Clean-contaminated wounds are made into contaminated areas, such as the respiratory, alimentary, or urogenital tracts, but without significant spillage. The same ventral midline laparotomy combined with a pelvic flexure enterotomy is a clean-contaminated surgery. The laparotomy is the clean component, and the pelvic flexure enterotomy is the contaminated component of the procedure.

Contaminated wounds have pre-existing inflammation, but infection has not become established by the time of surgery. Open, fresh traumatic wounds, which are common in the horse, are classified as contaminated. Surgical incisions with a known, serious break in aseptic technique (e.g., bowel rupture with gross spillage) also are classified as contaminated.

Dirty or infected wounds have pus present at surgery. Lancing an abscess is "dirty" surgery. Debridement of distal limb wounds that are heavily contaminated with hair, feces, and soil is frequently classified as dirty, regardless of the time duration or the stage of inflammation.

Antibiotics given after surgery do not alter the incidence of postoperative infection. Failure to give antibiotics preoperatively, so they can be present in the tissue during the decisive period when contamination occurs, is one of four major abuses of antibiotics in the management of surgical patients. The unnecessary administration of antibiotics to patients subjected to clean surgery, without implants, is another common abuse. Attempts to treat an undefined or undiagnosed fever in a postoperative patient is the third abuse. (However, the use of antibiotics to manage postoperative illness, which is common after colic surgery in horses, constitutes therapy, not prophylaxis.) Last, it is common practice to continue "prophylactic" antibiotics for 3 to 7 days after equine surgery or "until the catheters come out." This is the fourth major abuse of antibiotics in the management of surgical patients. The outcome of bacterial contamination is decided within a few hours of its occurrence.[1] If effective antibiotics have been given preoperatively and if the degree of contamination has been controlled, the prophylaxis should not be continued longer than 24 hours. Although there are no published studies in the horse, there is extensive human literature and evidence from cattle that single-dose or 24-hour prophylactic levels are as effective as extended antibiotic administration.[2–4] Prolonged antibiotic use may provide a false sense of security to the surgeon by delaying the development of signs of infection. When postoperative infections do occur in patients that have received prolonged prophylactic therapy, they often are suprainfections involving uncommon, resistant bacteria

that are more difficult to detect clinically and more difficult to manage.

The economic value of individual horses and the difficulty in veterinary surgery of establishing and maintaining a clean wound environment have been used as excuses for justifying the administration of potent, broad-spectrum antibiotics in less than rational circumstances. Antibiotic prophylaxis is most effective when a single effective drug is used to inhibit the colonization of a specific organism (e.g., penicillin for *Streptococcus* spp). Prophylaxis is doomed to failure if the surgeon hopes to prevent colonization or infection by any and all organisms from any source. The presence of bacteria and the horse's natural resistance must be kept in perspective. The horse cannot be "sterilized" by throwing a broad-spectrum blanket of antibiotic protection over it. Such a shotgun approach only predisposes to the emergence of amphibiontic organisms; these are opportunistic organisms that are normally noninvasive and relatively nonpathogenic.

There are numerous reports of such opportunistic infections in horses. In these instances, the emergence of antibiotic-resistant bacteria in certain geographic regions with valuable horses has been attributed, in part, to therapy with antibiotics that are not commonly used to treat less expensive animals.[5–7] Many university hospitals have experienced outbreaks of antibiotic-resistant infections in their equine patients and have reported concerns about the role of antibiotic use in such circumstances.[6–11] Common gram-negative coliform bacteria, *Salmonella* spp, and an otherwise nonpathogenic saprophyte have caused infection. Regarding the coliforms, up to 50% of the isolates were reported to be resistant to gentamicin.[11] The increased resistance was believed to be in association with the increasingly frequent use of gentamicin. Salmonella organisms are known to develop antibiotic resistance over the course of an epizootic salmonellosis outbreak, and horses treated with antibiotics are at significantly greater risk of becoming infected and subsequently experiencing diarrheal disease.[5, 7, 9, 10] The nonpathogenic saprophyte, *Serratia marcescens*, has been involved with single-organism and mixed infections of various tissues in 23 horses that were stressed and receiving antibiotic therapy; these infections resulted in a 35% mortality.[8] It would be misleading to suggest that antibiotic resistance and hospital outbreaks are the singular result of antibiotic misuse in surgical prophylaxis, but all antibiotic use in a hospital environment contributes to the microbiologic milieu that is present. Paradoxically, there are reports from some human hospitals, and anecdotal evidence from veterinary hospitals as well, that infection rates have decreased, with no apparent ill effects on the outcome of the infections that do occur, when all prophylactic and therapeutic antibiotic use is discontinued.[12] Infection must be viewed as an individual affair involving the host, its different tissues, and different microorganisms. The value of the horse, or the wound environment after the decisive period, has nothing to do with it!

There are many other potentially harmful effects of antibiotic prophylaxis. It has been suggested that their use leads to a psychologically relaxed adherence to aseptic principles. In addition to the possible selection of resistant bacteria, by suppressing the normal microbiologic flora, antibiotics may be immunosuppressive. Certain of these drugs are known to cause a decrease in neutrophil function, including chemotaxis and phagocytosis. Antibiotics, particularly penicillin, can cause acute drug reactions, allergies, and death. The aminoglycosides are known for their nephrotoxicity and may potentiate the neuromuscular blockade and cardiovascular depression associated with general anesthesia. The nephrotoxicity is magnified in dehydrated horses that are also receiving nonsteroidal anti-inflammatory drugs, a common scenario in horses with colic that are subjected to surgery. A significant decrease in blood pressure has been reported in awake and anesthetized horses minutes after the intravenous administration of sodium penicillin.[13] These adverse effects reinforce the importance of rehydrating and physiologically balancing compromised horses before surgery and of administering prophylactic antibiotics before giving the preoperative sedative drugs or inducing anesthesia; it is better prophylaxis and safer for the horse.

Antibiotics are irritating and may cause myositis or phlebitis after parenteral administration. Such irritation may, in turn, cause fever. Antibiotics may mask remote infections, the presence of which may be far more consequential to the results of surgery than the use or nonuse of antibiotics per se. Unnecessary antibiotics mean unnecessary expense. If the infection rate for a surgical procedure is 10% without antibiotic prophylaxis, then routine prophylaxis would unnecessarily expose 9 of 10 horses to antibiotics.[12] It is well established in human surgery that young, inexperienced surgeons use antibiotics more than senior surgeons do. Although there is no evidence, we believe the same trends occur in veterinary surgery. It has been shown that the administration of antibiotics significantly reduces the frequency of wound infection for clean surgical procedures performed by senior veterinary students, but not for similar procedures requiring less than 90 minutes to complete when performed by residents or faculty.[14] Because younger surgeons use antibiotics more than senior surgeons do, the question must be at what stage does one stop relying on them unnecessarily? Obviously, the consequences of surgical infection will guide the decision about whether to use antibiotic prophylaxis in any given circumstance, but surgeons need to think about the biology of the wound in reaching a decision rather than being influenced by the extraneous factors that can be controlled in other ways. The wound is the common denominator of all surgeons; our failure to

understand wound biology will not be compensated for by the use, or abuse, of antibiotics.

Regardless of the cautions about and limitations of prophylactic antibiotics, there are many equine surgical procedures for which their use is appropriate or indicated. General guidelines are given in Table 6–1, and we have identified our recommendations and preferences for each procedure in this atlas. Generally, we do not use prophylactic antibiotics for clean surgical procedures of soft tissues in the absence of implants (e.g., cryptorchidectomy). However, because of the consequences of infection and the large size of the braided suture material that is used for cricoarytenoideus dorsalis muscle replacement as a laryngeal prosthesis, perioperative antibiotics limited to 24 hours are used for this type of clean procedure. In most cases, penicillin alone has been used. Similarly, for elective orthopedic procedures with implants (e.g., lag screws), perioperative antibiotics are used. The anticipated length of an operation and the presence of remote infection also will influence our judgment about prophylaxis for clean procedures. The "dosage" of bacteria to the tissue does increase over time. When the surgery is expected to last much longer than 60 minutes, we are inclined to use perioperative antibiotics, administering the drug before surgery. Occasionally, two or more procedures are performed on the same horse by a team of surgeons; prophylactic antibiotics are frequently given in those cases. When remote infection is known to be present (e.g., a toe abscess in a limb to be subjected to distal check desmotomy), perioperative antibiotics are used. In these situations, penicillin G potassium,[a] 22,000 U/kg, as an intravenous bolus just before and repeated 4 hours after surgery is sufficient.

Clean-contaminated procedures are a mandate for prophylactic antibiotics. We administer penicillin G potassium, 22,000 U/kg, and gentamicin,[b] 6.6 mg/kg, as an IV bolus before inducing anesthesia in all colic patients. This dose of gentamicin has been established to be effective against 90% of all *Escherichia coli* for approximately 2 hours in the normal small intestine and for 4 hours in the normal large colon.[15] After surgery, the penicillin is repeated at 6-hour intervals and the gentamicin at 24-hour intervals as needed.[16] If the horse is healthy and metabolically balanced before surgery and if the intraoperative contamination was minimal, antibiotics are discontinued after 24 hours. For sick horses, or when the contamination has not been strictly controlled, the continuation of antibiotics beyond 24 hours is considered to be therapeutic rather than prophylactic. Although metronidazole[c] is not used prophylactically in our hospital, the emergence of penicillin-resistant obligate anaerobes has led us to use this drug therapeutically when pre-existing peritonitis is identified during surgery or when postoperative clinical parameters support the development of peritonitis.[17]

The use of antibiotics in the presence of orthopedic trauma requires special mention, complicated orthopedic procedures being different from routine elective procedures. Antibiotics can easily penetrate normal bone, but the periosteal and nutrient arterial blood supplies are severely compromised by fracture or by chronic disease. Bone that has been stripped of periosteum acutely or that is chronically encapsulated by dense fibrous tissue is not penetrated well by antibiotics administered parenterally. In the case of clean-contaminated equine bone surgery (i.e., internal fixation of open fractures), "prophylaxis" is probably the wrong term. Because more than 50% of these cases have positive intraoperative cultures and become infected, "early therapy" probably is a better term.[18] Because of the frequency of β-lactamase–producing *Staphylococcus* spp and the gram-negative Enterobacteriaceae with equine bone infection, first-generation cephaloporins[d] and amikacin,[e] drugs that are not recommended for prophylaxis for routine elective orthopedic procedures, are used in a combination prophylactic–continued therapeutic mode for the fixation of long bone fractures with implants.[19] The first-generation cephalosporins obtain excellent penetration of normal and osteomyelitic bone, and currently, most gram-negative organisms are sensitive to amikacin. Depending on both local and systemic developments, the duration of therapy after long bone fracture repair may range from 3 days to weeks.

A major limitation to the extended use of antibiotics in complicated orthopedic patients is the phenomenon of bacterial adhesion to biomaterials.[20, 21] Bacteria have an adaptive ability to colonize the surfaces of inert biomaterials; in the case of orthopedic patients, this includes the surfaces of metallic implants or dead bone. After surgery, there is a "race" between tissue cell integration with the inert surface and bacterial adhesion to the same surface. The bacteria form a protective exopolysaccharide glycocalyx, a film or "slime" that insulates the microorganisms from antibiotics, neutrophils, antibody proteins, and other immune mechanisms. During the initially vulnerable period, before the surface is stabilized, antibiotics to which the bacteria are sensitive may be used protectively.[21] Thereafter, bacteria remain alive and insulated by the protective biofilm, even after weeks of intensive antibiotic chemotherapy.[20] When the therapy is discontinued, generalized infection becomes re-established. In light of the ancient

[a]Penicillin G potassium, Marsam Pharmaceuticals, Inc., Cherry Hill, NJ.

[b]Gentocin, Schering-Plough Animal Health Corp., Kenilworth, NJ.

[c]Metronidazole tablets, USP, Sidmak Laboratories, Inc., East Hanover, NJ.

[d]Cefazolin sodium USP, Marsam Pharmaceuticals, Inc., Cherry Hill, NJ.

[e]Amiglyde-V, Fort Dodge Laboratories, Inc., Fort Dodge, IA.

Table 6–1.

Indications for Antibiotics

Type of Surgery	Type of Antibiotic
Skull, Head, and Neck	
Sinus trephination	N
Frontonasal flaps	P/T
Extraction and repulsion of cheek teeth	P/T
Repair of facial fractures	P
Repair of mandibular/maxillary fractures	P/T
Dentigerous cyst excision	N
Modified Forssell's operation	N
Gastrointestinal	
Esophagotomy	N
Cervical esophagostomy	N
Ventral midline celiotomy	N
Enterotomy	P/T
Intestine resection and anastomosis	P/T
Large colon resection	P/T
Colopexy	P/T
Flank laparotomy	N
Loop colostomy	P/T
Indwelling rectal liner	P/T
Rectal prolapse	P/T
Respiratory	
Excision of nasal epidermal inclusion cysts	N
Resection of alar folds	N
Laryngotomy/sacculectomy	N
Laryngoplasty	P
Arytenoidectomy	P/T
Sternothyrohyoideus myectomy	N
Staphylectomy/epiglottic augmentation	N
Treatment of epiglottic entrapment	N
Excision of subepiglottic cysts	N
Approach to guttural pouch	P/T
Fenestration of medial septum of the guttural pouch	P
Ligation of internal caroid artery	N
Tracheotomy	N
Ophthalmic	
Subpalpebral lavage	N
Entropion surgery	N
Third eyelid excision	N
Transpalpebral enucleation	N
Correction of nasolacrimal duct atresia	N
Male Reproductive System	
Castration	N
Cryptorchidectomy	N
Inguinal herniorrhaphy	N
Penile amputation	N
Female Reproductive System	
Caslick's procedure	N
Urethral extension for vesicovaginal reflux	N
Female Reproductive System Continued	
Rectovestibular fistula repair	N
Third-degree perineal laceration repair	N
Ovariectomy by colpotomy	P
Ovariectomy by laparotomy	N
Cesarean section	P
Urinary	
Resection of umbilical cord remnants	P/T
Ruptured urinary bladder repair	P
Perineal urethrotomy	P
Suprapubic laparocystidotomy	P
Fracture Repair	
Lag screw fixations	P/T
Lag screw fixation of third carpal slab fractures	P
Repair of condylar fractures	P/T
Repair of proximal phalangeal fractures	P/T
Excision of apex of proximal sesamoid	N
Excision of distal splint bone fractures	N
Osteostixis	N
Harvesting cancellous bone grafts	P
Half-limb cast	N
Half-limb cast with transfixion	P/T
Full-limb cast	N
Musculoskeletal System	
Palmar digital neurectomy	N
Navicular suspensory desmotomy	N
Navicular bursotomy	P/T
Arthrodesis of the proximal interphalangeal joint	P
Palmar/plantar annular ligament division	N
Resection of carpal flexor retinaculum	P
Distal check desmotomy	N
Proximal check desmotomy/percutaneous tendon splitting	P
Deep digital flexor tenotomy	N
Periosteal stripping	N
Transphyseal bridging	P
Cunean tenectomy	N
Arthrodesis of distal tarsal joints	P
Semitendinosus tenotomy	N
Lateral digital extensor myotenectomy	N
Medial patellar desmotomy	N
Suprascapular nerve decompression	N
Regional antibiotic perfusion	P/T
Abdominal Wall	
Umbilical herniorrhaphy	N
Mesh repair of large body wall defects	P
Integumentary	
Pinch grafting	N
Tail amputation	N

N, no prophylactic antibiotics; P, prophylactic antibiotics; P/T, prophylactic and therapeutic antibiotics.

and highly adaptive characteristics of bacteria, surgeons must be judicious in their use or discontinuance of antibiotics in difficult cases and look to surgical means of managing infection (i.e., sequestrotomy, saucerization, implant removal), including methods that are believed to create regionally high concentrations of antibiotics that can penetrate thick fibrous tissue, ischemic tissue, and biofilms (see Chapter 80).

We try to avoid the use of prophylactic antibiotics for dirty surgery. They are not used when abscesses are lanced. The mere fact that the horse has isolated and walled off the infection is evidence of a competent immune system; antibiotics should not be necessary. There is one exception. Dental and sinus surgery in the horse is dirty surgery, but these patients seem to respond better if a course of penicillin treatment is instituted before surgery and continued for 3 to 5 days. Although the evidence is entirely anecdotal, the appetite and general demeanor is better and the amount of facial cellulitis is less after procedures like trephination or the creation of a frontonasal bone flap in those horses that receive penicillin.

In summary, prophylactic antimicrobials will remain an integral part of the care of surgical patients. They should not be required for aseptic (clean) surgery in healthy patients because they can increase the risk of infection and induce antibiotic resistance. Antibiotics are important for clean-contaminated surgery and we must use them, but the surgeon's technical skill is still the most important factor in creating a wound that is inhospitable to bacteria. We must have a high threshold of awareness of the limitations, even when antibiotics are indicated or required. In this regard, it is better to be thoroughly familiar with a few well-established antibiotics with which many infections can be adequately treated rather than using every new agent that hits the market. We must resist the temptation to blindly continue to use the most powerful and often the most expensive antibiotics available, remembering that ineffective antibiotic therapy is worse than no antibiotic therapy at all.[12]

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two

surgical procedures

Skull, Head, and Neck Surgery

chapter 7

Sinus Trephination

Trephination of the frontal and maxillary sinuses can be performed for both diagnostic and therapeutic purposes. Chronic, unilateral purulent nasal discharge is the primary sign associated with paranasal sinus empyema in the horse. Bulging of the facial bones with distortion of the head may accompany long-standing sinusitis or result from tumors or alveolar periostitis. Dental disease accounts for half the cases of sinusitis in the horse[1] and must be kept in mind when trephination is contemplated. Percussion of the sinuses and radiography may not be diagnostic.

Diagnostic trephination can confirm the presence of pus in the sinus; permits aspiration of sinus contents for cytology, biopsy, or culture and sensitivity testing; and provides a portal for therapeutic irrigation. A frontal sinus portal will permit endoscopic examination of the frontal and caudal maxillary sinuses using arthroscopic equipment.[2, 3] Similarly, a caudal maxillary sinus portal can be used to examine the sphenopalatine sinus endoscopically.[2] Sinus trephination is easy to perform, provides valuable information, and has minimal complications.

Anesthesia, Positioning, and Surgical Preparation

Diagnostic trephination is performed on the standing horse using local anesthetic infiltration and chemical restraint when needed. If endoscopic examination is anticipated, some surgeons prefer general anesthesia to reduce the risk of damage to their arthroscopy equipment. The trephine site is clipped and routinely prepared for surgery. Although the sinus portal should not be made through unclipped skin, the clipped site can be small (2 cm^2) if the owner has reason to request minimal hair removal. Up to 5 ml of local anesthetic is injected to create a skin bleb and to infiltrate the underlying periosteum. Drapes are unnecessary, but a self-adhering impervious drape[a] may be used, provided that its application (and removal) does not interfere with the horse's eyes or otherwise create anxiety in the patient. The surgeon should don sterile gloves, use autoclaved

[a]Ioban 2 antimicrobial film, Animal Care Products, 3M Health Care, St. Paul, MN.

instruments, and prevent contamination of the "working end" of instruments from surrounding unclipped skin.

Surgery

Trephination sites for the frontal sinus (1 and 2) and the caudal compartment of the maxillary sinus (3) in mature horses are illustrated in Figure 7–1*A*. Slight variation from patient to patient is determined by the age, conformation of the head, stage of dentition, and any bulging that may be present. For the frontal sinus, the trephine portal should be 3 to 4 cm caudal to the rostral aspect (the divergence of nasal bones) of the sinus and 3 to 4 cm lateral to the midline. For access to the frontomaxillary ostium, the more lateral position is the most direct. Trephination of the caudal compartment of the maxillary sinus is performed 1 to 2 cm dorsal to the facial crest and 7 to 8 cm caudal to the rostral end of the facial crest. The bony septum that separates the rostral and caudal compartments of the maxillary sinus is variable in location and may be naturally perforate or may be eroded by sepsis. The sinus portal for the caudal compartment should be behind the septum. Disease of the rostral compartment usually results in facial bulging, which helps to determine the trephination site. The infraorbital foramen and nasolabial levator muscles can be palpated as a guide to avoiding these structures.

A 1-cm stab incision of skin and periosteum is sufficient for diagnostic trephination. A Steinmann intramedullary pin, 3/16 or 1/4 inch in diameter, is used to penetrate the bone. The pin should be chucked with just sufficient trocar point exposed to penetrate the bone, but without risk of damaging deeper structures (Fig. 7–1*B*). Because the horse is standing and conscious and can move its head, excess pin length protruding from the handle of the pin chuck is a potential weapon and should be guarded to protect the surgeon. The portal provides access for aspiration, biopsy instruments such as Ferris Smith rongeurs,[b] a 4-mm arthroscope for inspection, and a lavage catheter. If sepsis is suspected and pus does not drain freely from the site, the exudate may be inspissated. The sinus should be irrigated with warm, sterile polyionic solution and discharge from the nostril examined for evidence of pus. Lavage has therapeutic as well as diagnostic benefit and establishes nasal patency for the sinus compartment in question. The stab incision is not sutured.

These diagnostic approaches are useful for many conditions involving the sinuses (e.g., primary sinusitis, tumors) but not for sinusitis secondary to alveolar periostitis. Dental disease is identified by the characteristically foul smell that accompanies the nasal discharge, by oral examination, and by radiography. Dental disease requires a more aggressive sinus invasion (see Chapter 8).

There is occasional indication to establish a sinus portal in the standing horse using the Galt trephine.[c] The creation of a trephine site up to 2 cm in diameter requires a larger clipped area and up to 15 ml of local anesthetic infiltrated to create a 4- to 5-cm circular area centered over the site. The trephine saw is imprinted in the skin as the first step in establishing the incision margins (see Fig. 7–1*B*). A circular incision 2 mm larger than the imprint (*inset 1*) is made, and the island of skin is dissected free and discarded. A skin defect the same size as the saw blade creates soft tissue binding and impairs the cutting process. A cruciate incision is made in the periosteum and the quadrants reflected with the scalpel handle (*inset 2*). The trocar centering point of the trephine needs to be sharp and extended to properly seat the saw blade. Oscillating rotations are used to cut and ream out a circular plug of bone (*inset 3*). Because the saw blade is spring steel, twisting motion must be avoided during the cutting process to avoid breaking the naturally brittle blade. The bone plug should come away encased in the trephine blade. This approach allows digital palpation of the sinus cavity. The ventral conchal sinus can become involved with sepsis of any of the paranasal sinuses. It can be accessed, irrigated, and drained in the standing horse by Galt trephination of the frontal sinus.[4]

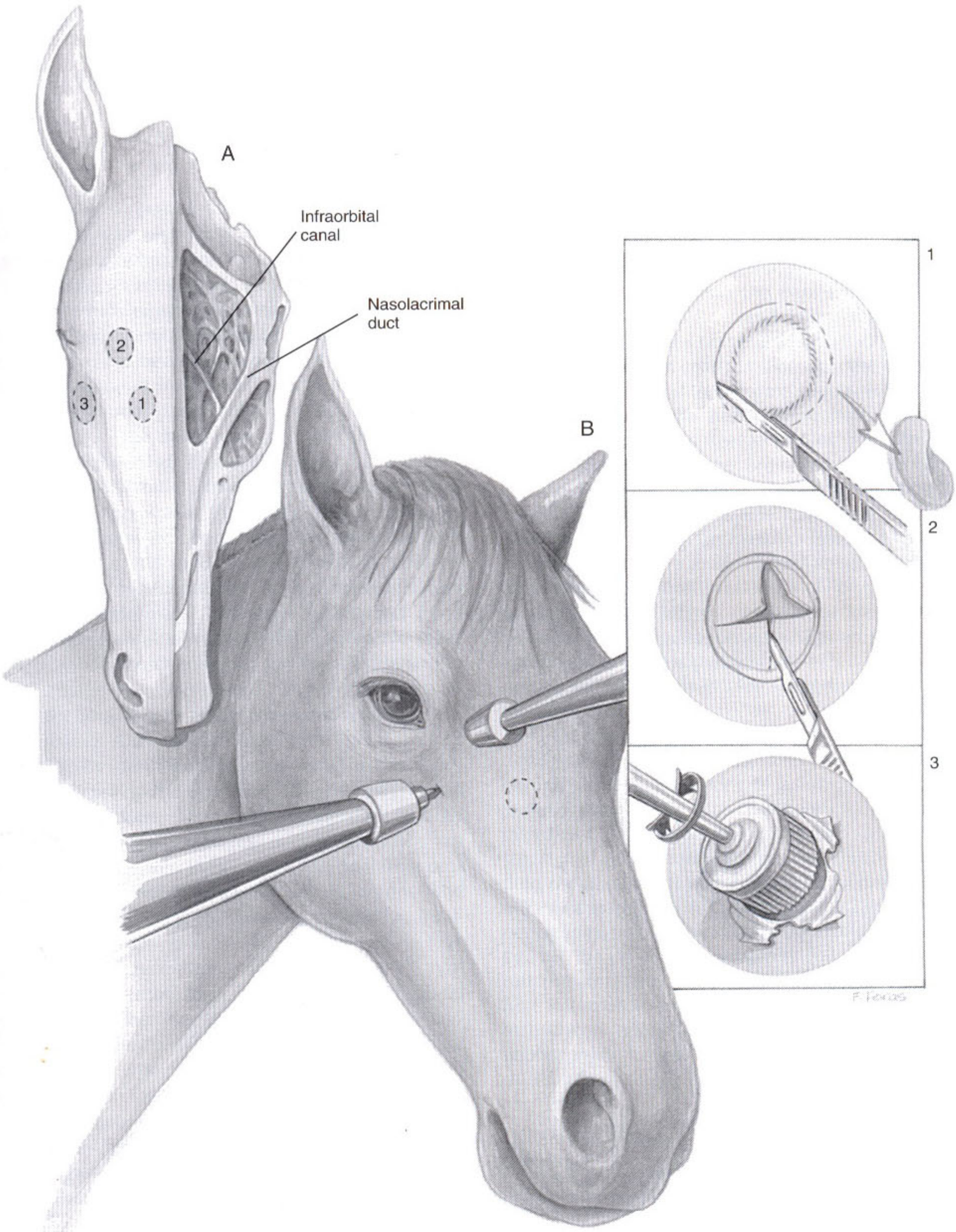
Postoperative Management and Complications

Management is directed at the primary diagnosis. The portal remains patent for 10 to 12 days for repeat invasion or irrigation. Thereafter, the formation of granulation tissue impairs access. The stab incision site for diagnostic trephination frequently develops a mild cellulitis with crusting or drainage, but no permanent blemish results. The cellulitis is aggravated when the incision is sutured. Secondary conjunctivitis may accompany the cellulitis but is not difficult to manage. The larger trephine hole heals within 3 to 4 weeks and, because the periosteum has been preserved, forms replacement bone. A small dimple in the face is usually palpable but is not unsightly when the hair has regrown. The biggest problem with these cases is the identification of underlying disease processes (e.g., tumors, alveolar periostitis) that cannot be managed via small portals or medically. The primarily diagnostic value, compared with the therapeutic value, of these approaches must be kept in perspective.

[b]Ferris-Smith rongeurs, Sontec Instruments, Englewood, CO.

[c]Galt trephine (Aesculap-Werke, Tuttlingen, Germany), Jorgensen Laboratories, Inc., Loveland, CO.

Figure 7–1.



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chapter 8

Frontonasal Flaps

Surgical treatment of some diseases of the equine head requires wide exposure and visualization of the sinuses, both of which are limited with trephination alone. Chronic sinusitis, cystic lesions of the paranasal sinuses, ethmoid hematomas, neoplasms, granulomatous diseases, congenital defects of the skull, and some dental diseases are best managed by a bone flap. Bone flaps can be limited in size, or a large flap involving most of the external plate of the frontal bone and the caudal aspect of the nasal bone can be made on one side of the midline (Fig. 8–1*A*).[1–3] A large flap provides for excellent visualization, thorough palpation, and surgical manipulation within the frontal sinus. Access to the ethmoturbinates, the dorsal conchal sinus, the ventral conchal sinus, the caudal compartment of the maxillary sinus, the sphenopalatine sinus (indirectly), and the turbinates and nasal chamber is provided by a frontonasal flap. In older horses with less reserve tooth crown, or when the disease process has destroyed the septum, a large frontonasal flap can provide access to the rostral compartment of the maxillary sinus as well. Vital structures such as the infraorbital canal and its contents can be identified and preserved. The nasolacrimal duct is lateral to the operative margins and encased in the lacrimal bone. The duct may be damaged by injury or disease (e.g., fractures, neoplasia), but is not vulnerable to iatrogenic injury when the operative procedure is correct. Many space-occupying lesions lend themselves to debulking followed by adjunctive treatment in an attempt to delay or prevent recurrence. Large flaps facilitate intraoperative radiotherapy, cryotherapy, hyperthermia, laser therapy, or intralesional chemotherapy. When the definitive diagnosis is uncertain, or when the extensiveness of a lesion suggests that multiple cavities within the head may be involved, and particularly when the margins are uncertain, a frontonasal bone flap approach is indicated. The surgeon must have a three-dimensional concept of the anatomy of the equine head and the benefit of a degree of adventurousness when undertaking these cases.

Anesthesia, Positioning, and Surgical Preparation

The frontonasal bone flap procedure, and surgical procedures performed via the flap, can be prolonged. Endotracheal intubation and inhalation anesthesia should be used. The horse is positioned in lateral recumbency with the affected side up. The head should be padded and tilted to enhance exposure and promote drainage through the nose. Some lesions distort the medial septum of the frontal sinuses and vomer bone with encroachment to the opposite side, but the bone flap approach is unilateral. Both trephination and a bone flap of the opposite side have been used to augment the debulking of massive lesions. The frontal, nasal, and maxillary areas of the face are clipped from the poll region rostrally and routinely prepared for aseptic surgery. If the surgery or gauze packing in the nasal chamber leads to postoperative respiratory obstruction, a tracheotomy site is prepared as well (see Chapter 36). An aseptic approach is warranted for the creation of the bone flap.

Certain diseases for which frontonasal flaps are used may cause blood loss anemia or the anemia of chronic disease. Debulking of lesions involving the ethmoturbinates results in profuse hemorrhage. We recommend that a suitable blood donor be identified before surgery. At a minimum, aggressive balanced electrolyte fluid replacement is performed intraoperatively. We use intravenous penicillin G potassium, 22,000 U/kg, as a perioperative antibiotic. Phenylbutazone, 4.4 to 8.8 mg/kg, can be given preoperatively for nonsteroidal anti-inflammatory therapy. A hand drill and 3.5-mm drill bit,[a] flat osteotome,[b] and mallet are the only special instruments needed to create a bone flap. Some surgeons prefer to use an oscillating saw[c] or a Hall air drill[d] and bur to cut the bone flap, but these instruments

[a]Hand drill, Zimmer, Inc., Warsaw, IN.
[b]Hibbs osteotome, Miltex Instrument Company, Inc., Bethpage, NY.
[c]Sagittal saw, Stryker, Kalamazoo, MI.
[d]Hall surgical micro 100 drill, Zimmer, Inc., Warsaw, IN.

are more expensive and create a saw kerf with loss of bone substance, resulting in a poor fit when the flap is repositioned. Other instrument needs (i.e., chisels, curets, rongeurs) are determined by the primary disease being treated.

Surgery

A contoured skin incision should follow the pattern of the bone flap (see Fig. 8–1*A*). The outside limits for the flap are the midline, the level of the supraorbital foramen caudally, and the end of the facial crest rostrally. The lateral limit of the incision is 2 cm medial to the medial canthus of the eye and follows the bridge of the nose. The corners of the skin flap are rounded, and the surgeon should keep the scalpel blade perpendicular with the skin to avoid tapered margins. A periosteal incision is made that follows the same contour of the skin, being inset from the skin margin by 2 mm (Fig. 8–1*B*). The periosteum is incised cleanly by keeping the scalpel blade in direct contact with the bone. The periosteum retracts slightly, but may need to be elevated and reflected from the bone for 2 to 3 mm. Bleeding is minimal to this point and is controlled easily with hemostats and electrocoagulation.

The margins of the bone flap are further inset by 2 to 3 mm from the soft tissue margins. When using an osteotome and mallet to elevate the bone flap, pilot holes are drilled at the extremities of the intended flap to aid positioning and guiding of the osteotome (see Fig. 8–1*B*). The osteotome must be sharp and held at a low angle with the bone plate to avoid early damage and hemorrhage from the underlying lesion. The osteotome also should be positioned to create a beveled edge to the bone margins, which aids repositioning of the flap at the time of closure (see Fig. 8–1*B*). Beveling can be hard or impossible to create when the bone plate has become devitalized by disease. If power instruments are used to cut the bone flap, the edges should be beveled, and care is taken in the process to avoid deep injury. In either event, the hinge ends of the bone flap are notched for 3 to 4 mm to aid fracturing of the medial margin (see Fig. 8–1*B*). Using two flat, broad chisels or osteotomes,[e] the bony septa between the deep surface of the external plate of the frontal bone and the underlying dorsal concha are broken down. The flat chisels serve as levers to fracture the medial margin and elevate the bone flap, periosteum, and skin as a unit (Fig. 8–1*C*). Bone flaps have been created wherein the skin has been reflected separately from the periosteum and bone, and wherein the skin and periosteum have been reflected together and the bone segment discarded. Invasive diseases that distort the face (i.e., neoplasms, granulomatous infections) can demineralize or devitalize the overlying bony plate, precluding salvage of the bone as a part of the flap. Such cases heal well when the skin and periosteum have been properly preserved and reconstructed. However, when possible, the skin, periosteum, and bone should be reflected as a single unit, particularly when large flaps are made.

The reflected flap should be kept covered and moistened with warm physiologic solution throughout the remainder of surgery. Work within the sinuses entails debulking of space-occupying lesions, complete ablation of the diseased sinus lining membranes, repulsion of involved cheek teeth, the use of adjunctive treatments, and the establishment of drainage of the conchal sinuses into the nasal chamber. These steps in the surgery result in profuse hemorrhage, which obscures visibility. The surgeon should work rapidly, lavage continuously, and depend on palpation to guide the debulking process. Occasionally, it is possible to pack off portions of the cavity while continuing to work in remaining portions. Dry packing applied under pressure should be used; epinephrine-soaked packs carry the risk of inducing cardiac arrhythmias in anesthetized horses.[1,3] Temporary bilateral occlusion of the carotid arteries has been used in the horse as a means of controlling hemorrhage,[2] but this approach is not without problems and imposes additional morbidity on the patient. We have not resorted to carotid occlusion.

Drainage openings into the nasal chamber should be large, with the redundant turbinate mucosa trimmed away.[4] Occlusion of drainage leads to persistent sinus infection, particularly of the ventral conchal sinus. A mare Chamber's catheter[f] can be inserted into the nasal ventral meatus to identify the site for drainage (Fig. 8–1*D*). All exposed cavities are accordion-fold packed with tubular gauze, with the end threaded through the nasal drainage opening and exposed at the external nare. The free end of gauze must be firmly packed in the nostril or sutured to the external nare to prevent dislodgement until it is removed. The packing can exit a trephine site if trephination has been performed. Packing should not exit through a corner of the bone flap reconstruction. The bone flap is repositioned. If the bone plate itself is unstable, it can be sutured in place with two to three simple interrupted sutures of size 1 polydioxanone placed through predrilled holes (see Fig. 8–1*D*). Usually, this is not necessary. The soft tissues are closed with a three-layer approach using simple interrupted or continuous sutures of size 2–0 or 3–0 polydioxanone[g] in the periosteum and the dermis and size 2–0 polypropylene[h] in the epidermis (see Fig. 8–

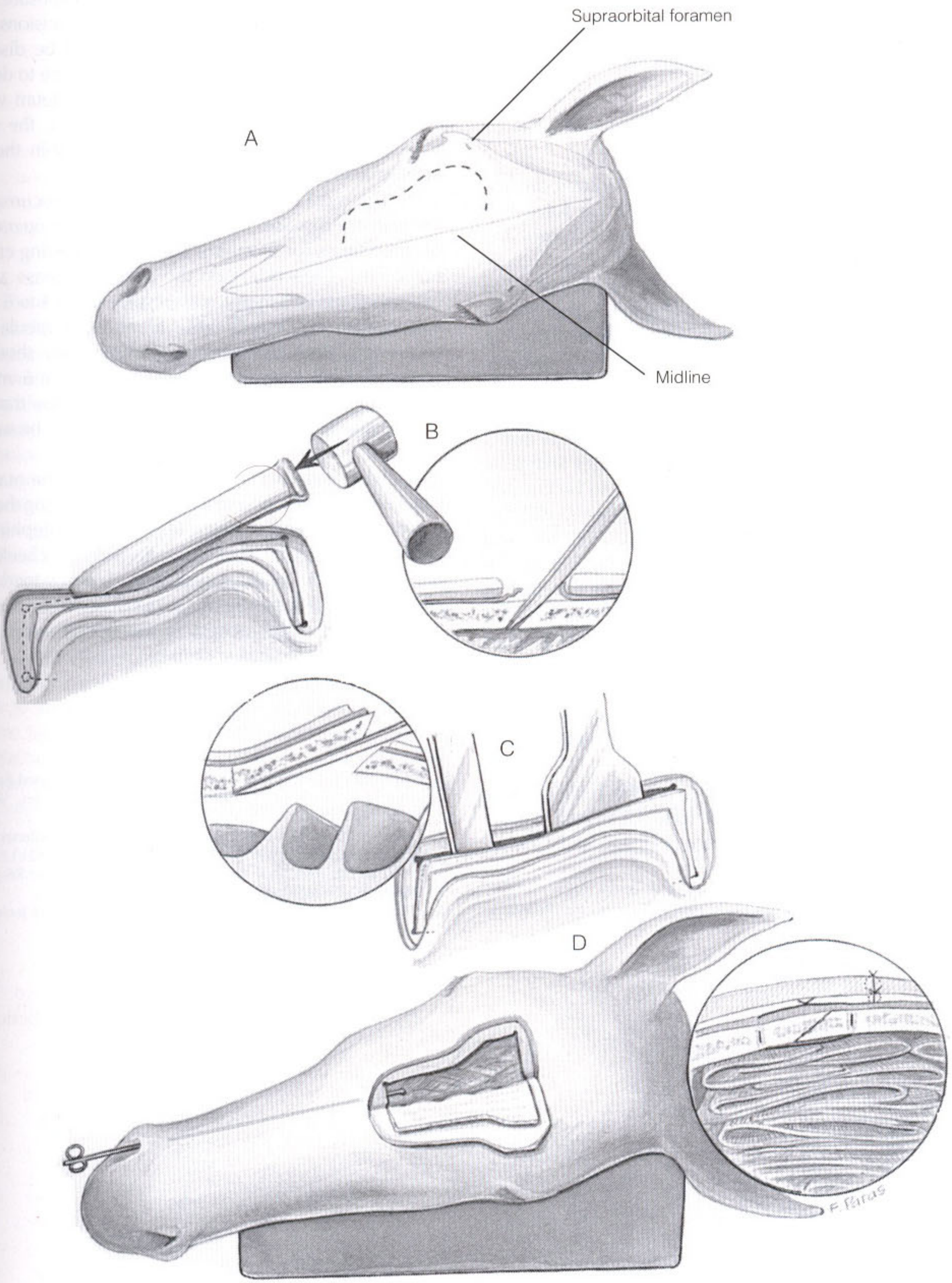
[e]Hibbs chisel, Miltex Instrument Company, Inc., Bethpage, NY.

[f]Metal catheter for mares (H. Hauptner, Solingen, Germany), Jorgensen Laboratories, Inc., Loveland, CO.

[g]PDS II, Ethicon, Inc., Somerville, NJ.

[h]Prolene, Ethicon, Inc., Somerville, NJ.

Figure 8–1.



1*D*). A sterile, dry dressing is placed over the flap incision, and the head is bandaged with elastic adhesive tape.[i] The horse is recovered from anesthesia in a padded head protector.[j] A tracheotomy should be performed when packing occludes the nasal cavity.

Postoperative Management

Space-occupying diseases of the sinuses are extensive by the time they are detected. We have had cases wherein bilateral sinus invasion has occurred and the debulking has invaded an orbit, both nasal chambers, and the mouth. The extensiveness of postoperative care will depend on the primary diagnosis, the degree of invasiveness, and the status of the patient. If postoperative antibiotics are indicated, the specific antimicrobial drug should be selected on the basis of culture of a tissue sample obtained during surgery. Most horses benefit from continued phenylbutazone therapy for 3 to 7 days. Few of these cases require stronger analgesic therapy. Tetanus immunization status should be current.

The packing can be pulled in segments, with all of the packing being removed by day 3. Pack removal may be accompanied by additional bleeding. A twitch or chemical restraint should be used when the pack is removed. If the remaining cavity in the head is to be irrigated, a separate trephine opening should be used (see Chapter 7) rather than placing an indwelling catheter through a corner of the bone flap. We advocate adequate drainage for sinus disease, as opposed to excessive irrigation, making certain that the opening into the nose is liberal.

Because of the blood supply in the head, reconstructed bone flaps heal well despite the contaminated nature of the surgery. Some serum drainage and clotting may occur along the suture line, but this does not appear to interfere with healing. We remove any bandages by day 3; we believe that air exposure is the better environment for healing of these incisions. If the bone plate is thin or crumbly, it should be discarded during surgery rather than being left in place to undergo potential sequestration. Remaining periosteum will regenerate new membranous bone. In fact, the reconstructive and remodeling capabilities within the head are remarkable.

The most important complication is recurrence of the primary disease. It is not uncommon to operate two or three times for problems such as a recurring ethmoid hematoma. Depending on the primary disease and the extensiveness of surgery, stall rest for up to 4 to 6 weeks is appropriate. Periodic re-evaluation, particularly radiographic and endoscopic re-evaluation, should be conducted no less infrequently than every 6 months. For benign diseases or for invasive diseases that have been completely removed, the outcome can be successful.

A bone flap can be performed over the maxillary sinus alone.[3,4] The primary reason for exposing the maxillary sinus is dental disease. We prefer trephination, rather than a bone flap, for repulsion of cheek teeth (see Chapter 9). Space-occupying diseases tend to fill several sinus compartments. A maxillary bone flap does not provide suitable access to the frontal and conchal sinuses or to the nasal chamber.

[i]Elastikon, Johnson & Johnson, New Brunswick, NJ.

[j]Surgical recovery hood, High Horse Therapeutic Products, Reno, NV.

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chapter 9

Extraction and Repulsion of Cheek Teeth

The primary reasons for surgical removal of cheek teeth in the horse are alveolar periostitis and the tooth loosening and gingivitis associated with old age. Alveolar periostitis is a disease affecting young horses, occurring during the first 5 to 7 years of life, and most frequently involves the maxillary fourth premolar and first molar.[1, 2] The permanent fourth premolar is the last cheek tooth to erupt in an arcade already crowded by pre-existing teeth. This pattern of eruption, combined with the gingival defects associated with shedding of the deciduous premolars and the periodontal disease that commonly accompanies eruption of the permanent teeth, predisposes to alveolar periostitis and may explain the age prevalence and specific tooth involvement.[2] Dental defects, such as a persistent infundibulum or congenital neoplasms, will allow bacteria to gain access to the alveolus and become apparent at or soon after the time of eruption. Young horses sustain injuries and fractures of the head. Maxillary and mandibular fractures frequently involve the cheek teeth and are open into the mouth, allowing the extension of oral bacteria to the tooth roots. Aged horses that have most of the reserve crown of their teeth erupted experience loose cheek teeth and secondary alveolar periostitis. Surgical removal of cheek teeth from a young horse can be a formidable undertaking, compared with that in an aged horse with shorter teeth and shallower alveoli. The cheek teeth decrease in diameter as they erupt, and the contact between the crowns is looser in older horses, which also aids removal.

Alveolar periostitis of the maxillary cheek teeth is characterized by secondary sinusitis with a foul-smelling ipsilateral nasal discharge. Bulging of the maxillary sinuses, with obvious facial deformity, is a late sign occurring after the inflammation has persisted long enough to occlude the nasomaxillary opening. Alveolar periostitis of the mandibular cheek teeth is characterized by heat, soft tissue swelling, osteitis, and eventual fistulization with drainage. Horses with alveolar periostitis can sustain all manner of signs referable to improper mastication, including quidding, balling feed in the cheek, lapping water, colic, and weight loss.

The definitive diagnosis of alveolar periostitis and the determination of the need for tooth removal are based on a complete oral examination and radiographs. It is important to both inspect and palpate the dental arcades. It may be necessary to "pick" the crowns, exploring the infundibula. We have used a 20-gauge, 1½-inch needle for this purpose in anesthetized horses. Chemical restraint of the patient, a suitable mouth speculum (Fig. 9–1), a good light source, and flushing of the mouth are essential. Diagnostic findings include an irregular table surface, broken crowns, feed accumulation, receding or bleeding gingival margins, the characteristic foul smell, and loose teeth. The absolute indication for tooth removal is a loose tooth. A molar forceps (see Fig. 9–1) may be required to determine whether the tooth is loose. Diagnostic radiographic findings include the disappearance of lamina dura around the tooth roots, various degrees of osteitis, and confirmation of the secondary maxillary sinusitis. Radiographs help to confirm the clinical findings, but radiographic changes are not used as the sole basis for surgical intervention.

Dental restoration, including periradicular surgery and endodontic therapy, is being evaluated in the horse.[3] Unfortunately, most cases of alveolar periostitis are too advanced for restorative techniques by the time they are detected, leaving extraction or repulsion as the only alternative. Extraction is not a difficult technique. It can be routinely successful when the tooth crown is present, the alveolar disease is sufficiently advanced, and the affected tooth is suitably loosened. When properly performed, extraction avoids the risk of damage to adjacent teeth. Timing of the extraction is critical. We have postponed surgery in early cases of alveolar periostitis for weeks to months, allowing the tooth to loosen, but intervening before the disease has spread to adjacent alveoli. A regimen of antibiotic and nonsteroidal anti-inflammatory therapy can be used to control the soft tissue swelling, but drugs will not cure the disease. Repulsion is used when the tooth crown is missing or breaks off during the process of extraction.

Anesthesia, Positioning, and Surgical Preparation

We have encountered the occasional old horse with short, very loose teeth that have been amenable to extraction with the patient standing and sedated, but we prefer general anesthesia for safety and convenience. If extraction fails, it must be followed by trephination and repulsion, which prolongs the procedure sufficiently to warrant inhalation anesthesia. The properly sized endotracheal tube can be passed per os without interfering with the surgery. The horse is positioned in lateral recumbency with the affected side up, but the head is padded to tilt the dental arcade and elevate the mouth for convenient manipulation and observation by the surgeon. An assistant is essential for positioning and stabilizing the head when the extraction forceps is positioned.

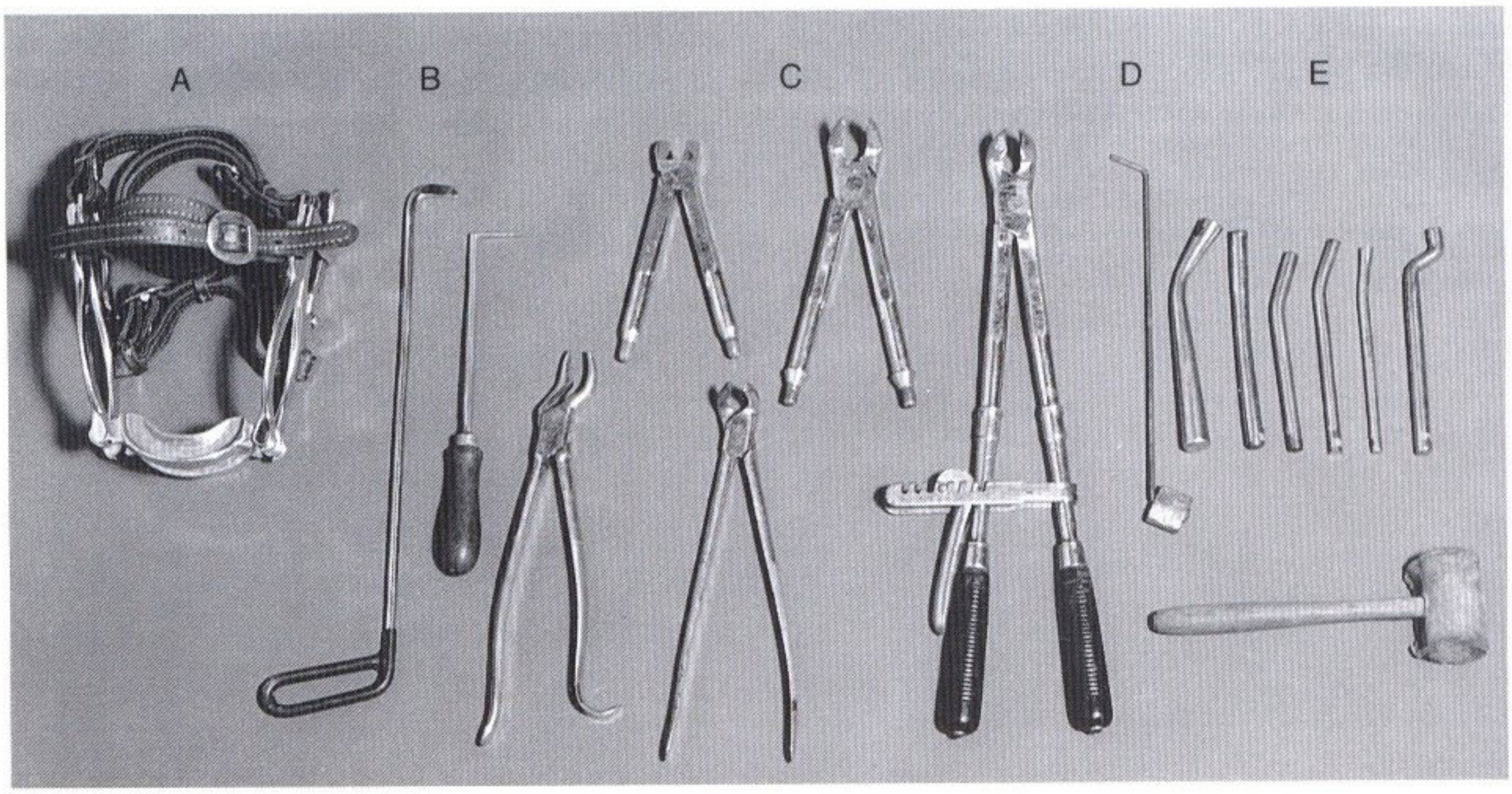


Figure 9–1.

Specialized instruments for dental extraction or repulsion. *A,* mouth speculum; *B,* periodontal probe and gingival elevator; *C,* Assorted extraction forceps with interchangeable handles and locking device; *D,* fulcrum; *E,* assorted dental punches and lead-lined leather mallet.

For extraction, no special preparation is required. The mouth should have been flushed out before endotracheal intubation, and the instruments should be kept wet in a bucket of dilute antiseptic. For repulsion, the trephination site is clipped and routinely prepared for sterile surgery, and the surgeon should don sterile gloves and use autoclaved instruments for invading the sinus or exposing the apical portion of the tooth. However, repulsion requires simultaneous manipulation at the root and crown ends of the involved cheek tooth, constituting a contaminated surgery. Perioperative penicillin G potassium, 22,000 U/kg, is administered as an intravenous bolus before induction of anesthesia. Dental surgery requires a full set of specialized instruments (see Fig. 9–1) in addition to those items required for trephination and curettage of the diseased sinus and alveolus. A McClellan or similar mouth speculum[a] is essential. Mouth gags that are inserted between apposing arcades are unsatisfactory for this surgery. They tend to slip out of position and occupy space in the mouth needed for oral manipulation. Long-handled periodontal probes or gingival elevators, extraction forceps, a forceps locking device or leather strap, molar cutters, and a fulcrum are required for extraction.[b] An assortment of various sized straight and curved dental punches and a lead-lined leather mallet are required for repulsion.[b]

[a]McClellan mouth speculum, Meister Co., Hampton, CT.
[b]Equine dental instruments, World Wide Equine Inc., Glenns Ferry, ID.

Surgery

Extraction[4]

Cheek tooth extraction is a surgical art requiring patience and a full understanding of the disease process. The first step is to elevate the gingiva with a periodontal probe from both the buccal and lingual surfaces of the crown; failure to do so will result in breaking of the crown. An extraction forceps with wide, short jaws is positioned over both the buccal and lingual surfaces of the full crown, and the handles are forcibly squeezed while an assistant affixes the locking device or leather strap (Fig. 9–2*A* and *B*). A severely diseased crown may break off in the process of setting the extraction forceps. With the forceps set, a gentle, slow movement of the handles is started from side to side within the mouth (see Fig. 9–2*B*). This rotates the tooth within the alveolus, breaking down the periodontal fibers, but no twist should be applied to the forceps handles at this stage. Early in the extraction process, the forceps jaws may loosen because of the crumbling of the irregular cementum ridges on the crown. The surgeon must palpate the crown and forceps, making certain that the forceps is not moving idly on the crown, and tighten the forceps locking device as needed.

When it is evident that the tooth is loosening, the length of the arc of side-to-side movement is gradually increased, and increasing force is applied at the end of each stroke (see Fig. 9–2*B*). Great patience is required during this stage of the extraction process. Haste will result in breaking of the crown. Most teeth loosen within 15 to 20 minutes and can then be extracted, but up to 45 minutes of twisting the tooth within the alveolus may be necessary before complete loosening occurs. As the periodontal fibers fatigue, blood accumulates in the alveolus, begins to clot, and makes a distinct sucking sound. This sound is evidence that the tooth is loose enough to apply a twisting or rocking motion to the extraction forceps handles as well as the side-to-side motion. When the handles can be rocked freely in lateral and tangential planes, the fulcrum can be positioned and the tooth elevated from the alveolus (Fig. 9–2*C*). Young horses with considerable reserve crown may not have sufficient space between the arcades to elevate the entire tooth. A molar cutting forceps is used to cut off a portion of the extracted tooth, and the extraction forceps is reset to complete the removal. The shallow alveoli in older horses can be left to heal as an open wound. In younger horses with long teeth, or in the event of sinusitis and apical osteitis, trephination, curettage, and lavage of the sinus or alveolus are necessary.

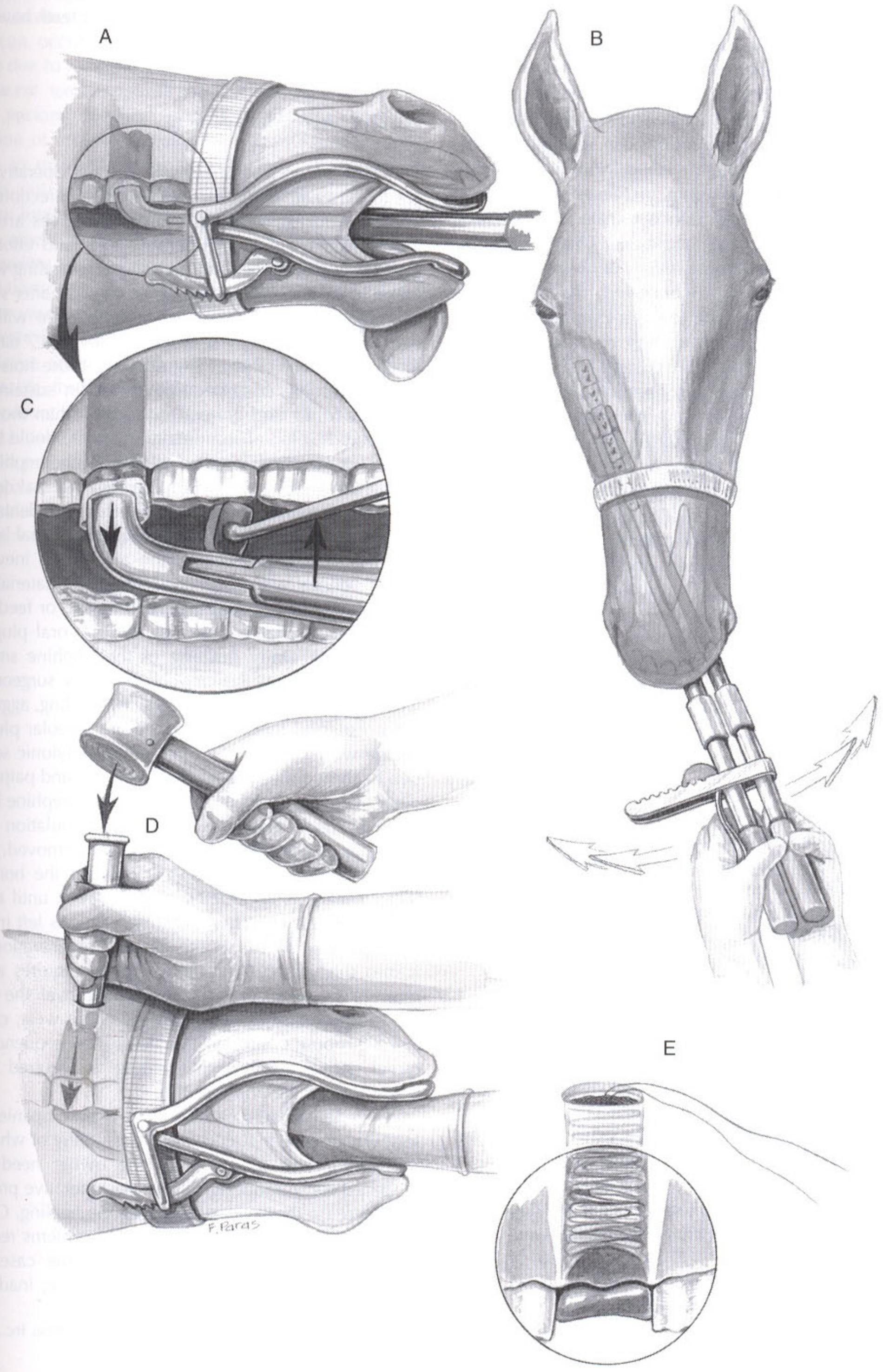
Repulsion[4]

Repulsion is necessary when the crown is missing or has been broken off in the act of extraction. This surgery requires a three-dimensional perception of the anatomy of the head, sinuses, and dental arcades. The landmarks for trephination (see Chapter 7) and for bone flap exposure (see Chapter 8) of the sinuses are precise, and the margin for error is minimal. We prefer trephination for tooth repulsion because closure of a bone flap at the conclusion of surgery precludes access to the healing alveolus. The location of the trephine site depends on the tooth involved and the age of the horse. With the mouth speculum in place and a hand in the mouth, a finger identifies the level of the affected crown by bulging the cheek. The trephine site is directly over the center of the table surface of the first four cheek teeth and over the caudal margin of the last two cheek teeth. For the maxillary third molar, the trephine site is the frontal sinus with the punch positioned through the frontomaxillary ostium. Reference to an equine maxilla and mandible, showing the location and configuration of the premolars and molars, is helpful at surgery.[4, 5]

Repulsion is easier when the punch is in a direct line with the long axis of the tooth. For the maxillary arcade, the trephine site should be as dorsal as possible, but just below the infraorbital canal. Levator muscles and facial vessels can be retracted dorsally from the site. For the mandibular arcade, the trephine hole is not made directly on the ventral aspect of the ramus. A 5- to 6-cm straight skin incision is made over the apex of the affected mandibular tooth and on the side of the mandible. The linguofacial vessels and parotid duct are preserved, and the masseter muscle fibers are separated to expose the ventrolateral aspect of the alveolus.[6] A large, 2-cm trephine saw should be used to provide maneuverability for the dental punch. Rongeurs or a bone chisel can be used to enlarge the trephine hole to aid placement and alignment of the punch. Curved and offset punches are often necessary to center the end of the punch squarely on the root of the tooth (see Fig. 9–1).

Before repulsion, the affected tooth should be loosened, if possible, with extraction forceps, as previously explained. Breaking the periodontal fibers with extraction forceps will make repulsion easier and require less mallet force. The surgeon holds the punch in one hand and positions a bare index finger of the other hand over the crown of the affected tooth in the mouth (Fig. 9–2*D*). An assistant taps on the punch repeatedly as the surgeon feels the crown, and both adjacent crowns, for vibrations that confirm accurate positioning of the punch. Misdirection of the punch axially or abaxially results in little or no vibration in the teeth. Such

Figure 9–2.



misdirection can result in punching through the hard palate with severance of the palatine artery. Hemorrhage can be profuse and severe. In the mandible, misdirection results in fracture of the ramus. When the punch is correctly positioned, the surgeon can feel vibrations in the diseased tooth and in both adjacent crowns, but the tapping pulsations are strongest in the tooth over which the punch is positioned. With the punch positioned, the assistant increases the force of mallet blows. Initially, the punch crushes through the alveolar bone overlying the tooth apex. This produces a dull sound with the feeling that the punch is advancing rapidly. When enamel is encountered, the sound becomes crisp and ringing. The use of a lead-lined leather mallet is important. The sound must emanate from the punch on the enamel, not from a steel mallet hitting a steel punch. Nylon-tipped orthopedic mallets are too light to effect repulsion. The surgeon continues to keep one hand in the mouth, monitoring the vibrations and constantly adjusting the punch alignment. When the surgeon is confident that the positioning of the punch is correct, the force of the mallet blows is further increased. Steady, repeated blows to the punch are used to fatigue the periodontal fibers and loosen the tooth. Patience is required. Hurried repulsion tends to fracture the tooth, resulting in partial removal, and can fracture adjacent alveolar bone. Long teeth may need to be divided with molar cutters before the whole tooth is expelled into the mouth.

The sinus and alveolus are thoroughly curetted to remove remaining fragments of enamel and all diseased bone and soft tissue. If maxillary sinusitis has been long-standing, the entire sinus membrane lining must be removed. We have encountered extension of infection to the frontal sinus as well, requiring separate trephination and drainage. Because hemorrhage tends to obscure vision, curettage is guided by palpation, and copious lavage is used throughout the surgery. The degree of bone involvement is always more extensive than indicated by the radiographs, and complete debridement usually takes longer than anticipated. The defect is tightly packed with tubular gauze[c] impregnated with a mild antiseptic, filling one half of the deeper portion of the alveolus and all of the sinus. The oral one half of the alveolus is packed with dental wax[d] that has been softened with hot water (Fig. 9–2*E*). The wax should completely fill the gingival defect and be molded to the adjacent crowns. Other products, such as polymethylmethacrylate or gauze rolls tied into the gingival defect, have been used to seal the alveolus, but we have had good success with dental wax when it has been properly applied. Polymethylmethacrylate[e] works well when two or more adjacent teeth have been removed and the oral defect is large.

[c]Sof-Band bulky bandage, Johnson & Johnson Medical Inc., Arlington, TX.

[d]Hygenic-Wax (pink base plate wax), IDE Interstate, Amityville, NY.

Postoperative Management

The objectives of surgery and postoperative care are to eliminate infection and prevent reinfection of the alveolus during healing. These objectives are challenges that require considerable time and effort. The horse is hospitalized until the wound is healing without complication. Normal feeding is resumed after surgery. Barring serious problems, most horses are willing to eat. Antibiotic therapy is continued for 5 to 7 days. On the basis of our clinical impressions, those horses that do not receive postoperative penicillin sustain more facial cellulitis and general discomfort than those that are treated. Tetanus immunization status should be current. The gauze packing is pulled from the trephine site within 24 to 48 hours of surgery, and the oral defect is palpated regularly to determine that the dental wax plug is secure. Some leakage of saliva and oral bacteria into the deeper portions of the alveolus is inevitable, but the dental wax seals out particulate material. Malodorous discharge from the trephine site or feed material in the discharge indicates that the oral plug must be replaced. Daily flushing of the trephine site with antiseptic solution is practiced by many surgeons, but we believe that daily flushing delays healing, aggravates the horse, and tends to dislodge the alveolar plug. We lavage with 200 to 500 ml of sterile polyionic solution two or three times during the first week and palpate the defect with a gloved finger through the trephine hole at 7 to 10 days, before it fills with granulation tissue. Remaining loose bone fragments are removed. When healthy granulation tissue has covered the bony surfaces, lavage is conducted twice a week until the trephine hole closes. The dental wax plug is left in place until granulation tissue and gingival regeneration force it into the mouth. Complete healing requires a minimum of 3 weeks. After cheek tooth removal, the opposing tooth continues its eruption without wear, creating a wave-mouth condition as a natural consequence. Frequent dental prophylaxis (floating) is required for the remainder of the animal's life.

Dental surgery in the horse is accompanied by a long list of potential complications, many of which are iatrogenic. The surgeon and the owner need to be prepared for intraoperative and postoperative problems that increase the cost and prolong the healing. Complication rates approaching 50% and problems requiring additional surgery in up to 50% of the cases have been reported.[1] Fractures of the mandible; inadvertent

[e]Surgical simplex P bone cement, Howmedica, Inc., Rutherford, NJ.

disruption of the palatine artery, the infraorbital canal, or the nasolacrimal duct; and removal of the incorrect tooth can occur.[1, 2] Persistent postoperative drainage can be due to remaining fragments of enamel, damage to adjacent teeth, sequestration of alveolar bone, retained packing or plugs, persistent sinusitis, and the formation of orosinus fistulas.[1, 2, 7] Granulation cannot adhere to exposed cementum. If all of the diseased tooth is not removed, or if the alveolar plate of an adjacent tooth is damaged with the resultant exposure of the cementum of the reserve crown, healing cannot be complete. In the event of an orosinus fistula, a muscle transposition technique has been described that provides vascular tissue to aid healing of the defect.[7]

With the possible exception of hemorrhage from the palatine artery, the complications of dental surgery are not life threatening. However, complications increase patient morbidity and cost. Surgery involving the more caudal maxillary cheek teeth carries the least favorable prognosis and the higher risk of complications needing a second surgery. In summary, dental extraction and repulsion are procedures that are technically within the realm of equine general surgery and can be conducted in the field. They are procedures that, when done poorly, result in problems and complications. Surgeons endeavoring to perform equine dental extraction or repulsion should have an awareness of the art and finesse that are associated with a successful procedure as well as a good understanding of dental and sinus anatomy.

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chapter 10

Repair of Facial Fractures

Skull fractures in horses are common and usually follow external trauma such as impacts with stationary objects or kicks by other horses. Membranous bones of the face, including the frontal, nasal, and maxillary bones, are vulnerable to depression fractures with resultant facial deformity. The underlying sinuses and nasal chambers are often damaged. Because of the bacterial flora of the sinuses and nose, facial fractures are open and predisposed to cellulitis, bone sequestration, secondary chronic sinusitis, and wound fistulation. The eye and its adnexa, particularly the orbit and nasolacrimal duct system, are commonly involved with facial fractures.[1, 2] The surgeon needs to accomplish orbital reconstruction in such cases to reduce the threat of permanent ocular deformity or blindness.

The diagnosis of facial fractures is based on the history, clinical signs, and radiographic findings. Observation and palpation of the skull provide the most important diagnostic information. The deformity of the face and the instability of bony fragments may be subtle or obvious. Soft tissue swelling may obscure the deformity initially. Recently injured horses resent manipulation of these wounds, and rough attempts to feel the defect or elicit crepitus may further depress bone fragments into the underlying cavities. Respiratory, ocular, central nervous, and cranial nerve function should be assessed. Air flow through the nostrils may be impaired. The hematoma underlying the fracture fragments may result in a hemorrhagic nasal or nasolacrimal discharge. Vision assessment and ophthalmoscopy should be conducted. A depressed palpebral reflex and traumatically induced uveitis are common with injuries to the orbital region. Facial fractures may cause central nervous system trauma. Head trauma requires prompt attention and constant monitoring when neurologic signs are present. Cranial nerve deficits can accompany facial fractures, particularly those occurring in the infraorbital region, or basilar skull fractures. Radiographic evaluation of the skull is important, but interpretation can be difficult.[2] Lateral, oblique, and ventrodorsal projections should be made. The bone damage is frequently worse than the radiographs reveal. A fluid line may be evident in the sinuses or the guttural pouches. The occasional horse may require nasopharyngeal or guttural pouch endoscopy for a complete assessment of the trauma and involvement.

Anesthesia, Positioning, and Surgical Preparation

Surgical wound debridement with repositioning and stabilization of facial bones requires general anesthesia. Horses are positioned in lateral recumbency, but when the facial depression is bilateral, access to the down side of the face can be limited. In such cases, the head should be positioned with the neck slightly twisted to maximize exposure to both sides of the face. Levering depressed bone fragments into normal position requires a wide skin and periosteal flap. A liberal area around the wound site, large enough to provide for wide dissection and reflection, is clipped and routinely scrubbed for aseptic surgery. A bone hook, chisels, rongeurs, drill bits and a drill, and stainless steel wire are required in addition to standard surgical instrumentation. Because these fractures are classified as open, perioperative antibiotics are warranted. We use penicillin G potassium, 22,000 U/kg, as an IV bolus, before and after surgery.

Surgery

Because all facial injuries are different, some ingenuity is required from case to case. Complete familiarity with the anatomic locations of the supraorbital and infraorbital foramina, the limits of the frontal and maxillary sinuses and nasal chambers, and the relative sizes of the facial bones and their sutures aids in planning and conducting the surgery.[2, 3] A large circumlinear skin flap that extends beyond the limits of the injury is elevated (Fig. 10–1*A*).[3] Large flaps better maintain the integrity of the dermal circulation, which is critical to good healing. Incisions should not be positioned directly over fracture fissures. The integrity of the periosteum may be in question. In some cases, the periosteum is stripped from the bone and becomes elevated with the skin flap. In other cases, it is devitalized and shredded beyond recognition, particularly when there is comminution with many small facial fragments. For large fragments that are to be elevated and stabilized, periosteal attachments should be left intact. The injury site is debrided, and small bone fragments are discarded. The underlying sinus or nasal chamber is exposed and lavaged with sterile polyionic solution. A clear flush through the nostril(s) establishes proper drainage and patency. It is helpful to be able to palpate and visualize the limits of the chamber(s). Depending on the severity of the injury and suspected deep involvement, trephination at a site remote from the fracture fissures may be warranted. Old hemorrhage and loose bone fragments are removed from the depth of the underlying chambers. We have seen cases in which the external trauma and facial depression were minimal, but implosion damage to the lacrimal and frontal bones of the orbit or the ethmoturbinates of the nose was extensive. Reconstruction of these deeper components of the skull is virtually impossible, but all loose fragments should be removed to avoid sequestration or interference with function.

Flat instruments such as a chisel[a] or a bone hook[b] introduced through an adjacent bur hole are used to elevate depressed fragments (Fig. 10–1*B*). Considerable force may be necessary to dislodge the fragment from its impacted state and reposition it into a normal position. Collapsed segments of the orbital rim can be elevated by external positioning of a bone hook between the globe and the palpebral conjunctiva.[2] Palpation is used to determine proper repositioning. Interrupted sutures of stainless steel wire threaded through predrilled holes are used to hold the fragments in place (Fig. 10–1*C*). The skin flap is sutured with size 2–0 monofilament synthetic absorbable material in three layers: subcutaneous, dermal, and epidermal. The skin of the face is relatively thin. Dermal and epidermal closure allows for the use of small-sized suture material and provides excellent apposition, which contributes to rapid epithelial bridging of the wound margins. Simple interrupted sutures are used to facilitate removal of several stitches if postoperative wound drainage occurs. Relaxing incisions with undermining and sliding of adjacent skin and periosteum may be necessary to cover the bone repair when soft tissue defects are present. The nasolacrimal duct system is flushed from the nasal punctum to determine its patency; this can be done as a final step or earlier during the surgery if the integrity of the duct is in doubt.

[a]Hibbs osteotome, Miltex Instrument Company, Inc., Bethpage, NY.

[b]Bone hook, DePuy, Warsaw, IN.

Postoperative Management

To provide counterpressure and to prevent subcutaneous emphysema from air escaping from the underlying cavities, the sutured incision is covered with sterile gauze and the head bandaged with elastic adhesive tape. The horse is assisted in recovery from anesthesia wearing a padded hood.[c] The hood is removed as soon as the horse has a normal sensorium, and the bandage is removed in 24 to 48 hours. Nonsteroidal anti-inflammatory therapy for 1 to 2 days may be helpful, but these horses seldom exhibit postoperative pain; analgesics usually are not needed. Postoperative complications include bone sequestration and sinusitis. These problems are averted by proper wound management. Provided that the surgeon is confident that debridement and lavage have been thorough, antibiotic therapy beyond the day of surgery is unnecessary. Wound healing is usually very good and is attributable to the excellent blood supply to the head.

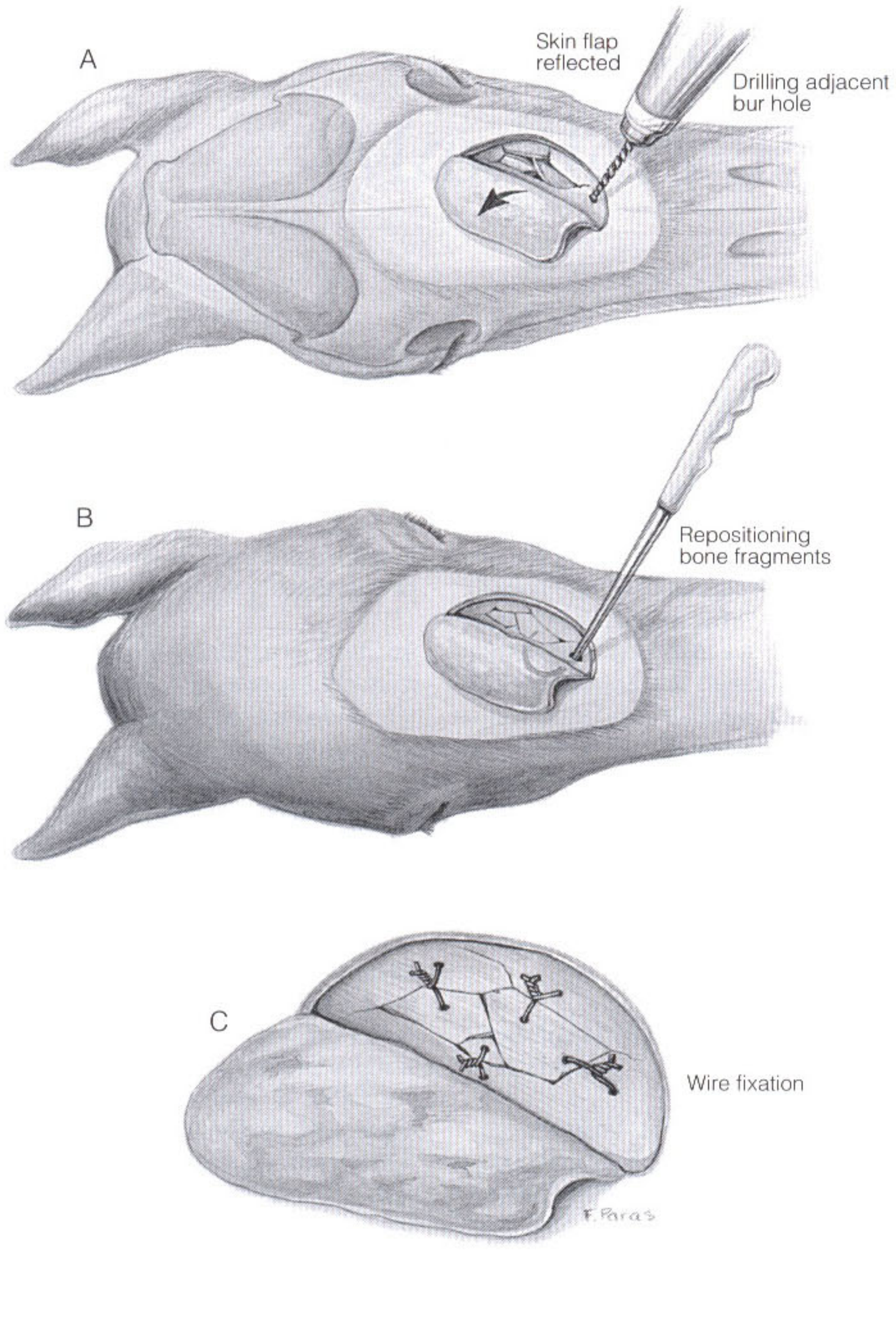
Facial fractures can heal without surgical intervention, but the chances for complications are greater and the deformity is permanent. Early repair is desirable, particularly if cosmesis is important. Techniques have been described for reconstructing the orbital floor in the event of a sunken globe and for restoring facial contour in the event of a permanently deformed facial contour.[4, 5]

[c]Surgical recovery hood, High Horse Therapeutic Products, Reno, NV.

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Figure 10–1.


A
Skin flap
reflected
Drilling adjacent
bur hole
B
Repositioning
bone fragments
C
Wire fixation
F. Paras

chapter 11

Repair of Mandibular and Maxillary Fractures

Fractures of the mandible are the most common fractures of the head. These fractures result from self-inflicted trauma and external violence. Young horses demonstrate curiosity and tend to get their teeth or heads caught, causing damage to incisors, the body of the mandible, and the median symphysis when they try to free themselves. These injuries are straightforward to evaluate and manage and usually respond favorably to treatment.

Fractures through the interdental space of the mandible may be unilateral or bilateral and are the most common variety. A unilateral fracture in the interdental space may go unobserved or require no treatment because the body of the mandible and the incisors remain stabilized by the cantilever support provided by the intact ramus. Bilateral fractures through the interdental space can be unstable and may involve marked displacement; surgical repair is essential. Fractures of those portions of the jaw that are protected by the masseter and pterygoid musculature are infrequent and the result of violent force (e.g., vehicular accident and kicks from other horses). Although surgical approaches are possible,[1, 2] many of these fractures do not require surgical treatment; the heavy musculature serves to splint the fracture while healing occurs. Fractures of the caudal portions of the mandible frequently involve the premolars or molars with the development of secondary alveolar periostitis (see Chapter 9). Fractures of the premaxilla and maxilla can be similar to those described for the mandible; external violence is the usual cause. Damage to the nasal septum and to sinus and facial structures frequently accompanies maxillary fractures.

Malocclusion of incisors is a common complaint and a hallmark of fracture of the mandible. Teeth may be loose, broken, or missing. The tongue frequently protrudes through the incisors. There may be facial or tongue paralysis. These fractures are invariably open into the mouth. Even minor displacement at the fracture site disrupts the gingival mucosa. Many horses with broken jaws try to eat, impacting feed material into the gingival defect, or they are reluctant to open their mouths and resent manipulation, which can be suggestive of tetanus or other neurologic involvement.

Radiographs are essential for defining the fracture, determining tooth involvement, and selecting the method of treatment. Lag screws, plates and screws, intramedullary pins, external coaptation, intraoral U-shaped braces, intraoral acrylic splints, and wiring have been used successfully.[3] The method of treatment is somewhat dependent on the nature of the fracture and the experience and ingenuity of the surgeon. Intramedullary pins can damage tooth alveoli, particularly in young horses. Plates and screws are expensive. U-shaped braces are tedious to position and secure to the premolars and do not always provide good stabilization. In our experience, wiring of teeth, wiring of the fracture fragments, and simple approaches to external fixation with pins and fixators are appropriate for most fractures and are relatively simple to apply.

Anesthesia, Positioning, and Surgical Preparation

General anesthesia is usually required to reduce and stabilize the fracture. For horses that resent examination of the mouth while conscious and standing, complete assessment of the injury, radiographs, and definitive treatment can be conducted during anesthesia. Continuous intravenous anesthesia may be sufficient when the anticipated repair procedure is expected to be 45 minutes or less, but inhalation anesthesia is recommended if there is doubt about the degree of involvement or the method of repair. Nasotracheal intubation improves access to the mouth. The horse is positioned in lateral recumbency for most mandibular fractures, but dorsal recumbency is a useful position if external fixation is to be applied or when the maxilla is fractured. The mouth is rinsed with water to remove accumulated feed material, and the gingival defect and

surrounding area are scrubbed with a povidone-iodine soap[a] and rinsed again. For wiring of teeth or direct wiring of fragments, additional preparation is unnecessary. For application of an external fixation device, the pin penetration sites are clipped, routinely scrubbed, and draped for aseptic insertion of the pins. Sixteen-gauge (1.35 mm) stainless steel wire,[b] needle holders or pliers, and wire cutters are the special equipment needed to wire teeth. Additionally, a 2.7-mm drill bit and drill are needed for the direct wiring of fracture fragments through predrilled holes. One-quarter-inch positive-profile centrally threaded pins,[c] a 6.2-mm drill bit[d] and tap with central threads,[e] an orthopedic drill, a pin chuck, an extra large Kirschner-Ehmer (K-E) apparatus,[f] and large pin cutters are necessary for treating bilateral interdental mandibular fractures that are widely displaced and unstable. One-quarter-inch Steinmann pins[g] can be used as an alternative to positive-profile pins. Penicillin G potassium, 22,000 U/kg as an intravenous bolus, before induction of anesthesia and repeated within the first 6 hours after surgery is commonly administered.

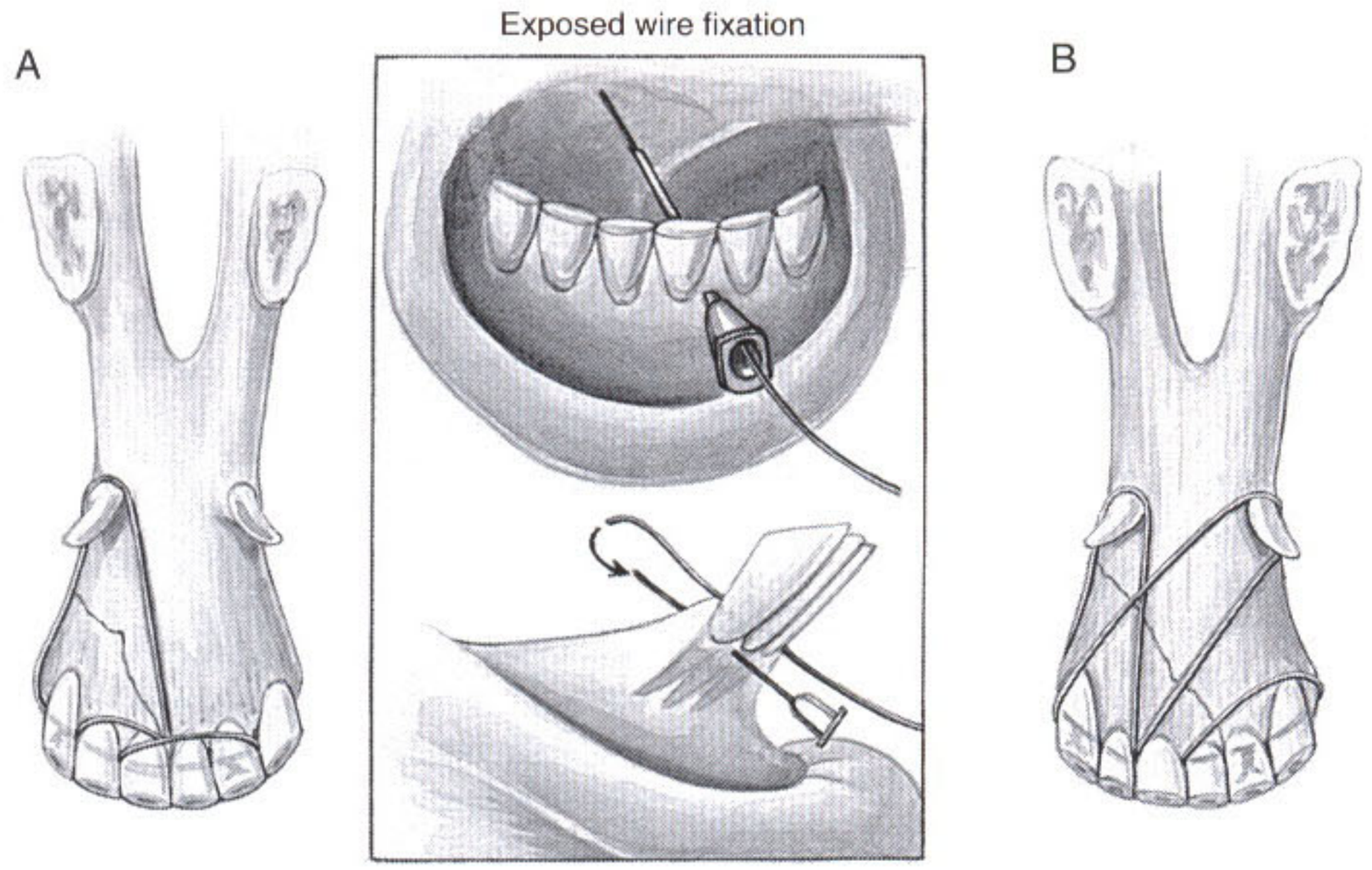
[a]Betadine surgical scrub, Purdue Frederick Co., Norwalk, CT.
[b]Stainless steel wire, IMEX Veterinary, Inc., Longview, TX.
[c]No. 21140 large-animal transfixation/casting pin with central thread, IMEX Veterinary, Inc., Longview, TX.
[d]6.2-mm orthopedic drill bit, IMEX Veterinary, Inc., Longview, TX.
[e]Tap with central threads for pin 21140, IMEX Veterinary, Inc., Longview, TX.
[f]External fixation components, Osteo-Technology International Inc., Timonium, MD.
[g]I.M. (Steinmann) pins, Osteo-Technology International Inc., Timonium, MD.

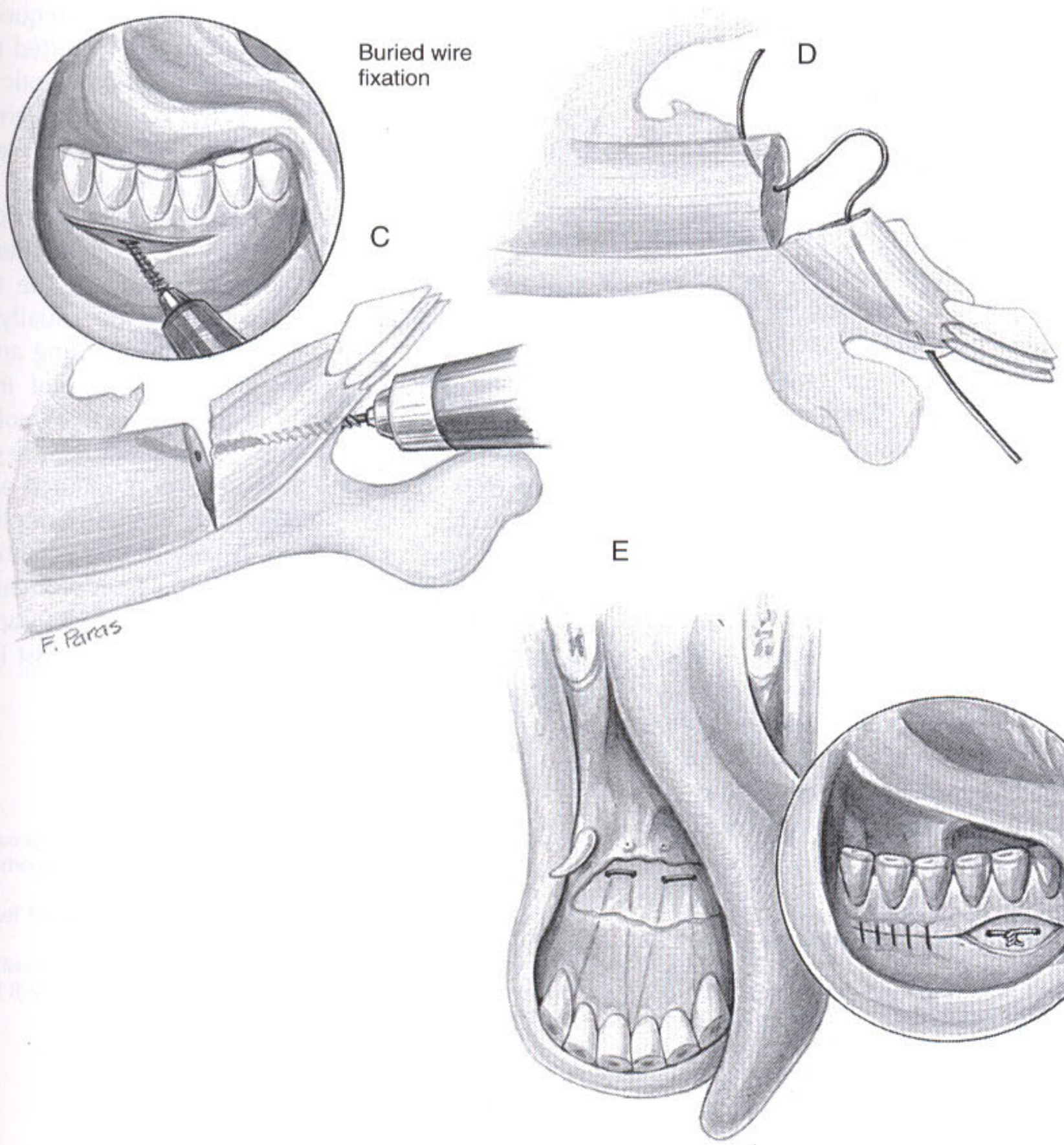
Surgery

Complete debridement of the oral wound is the first step in surgical repair. Tags of torn gingival mucosa are excised. Remaining food material, clotted blood, and bone fragments are removed. A curet is used to explore and freshen the fracture fissure. In young horses, loose deciduous teeth are removed. Debridement and tooth removal are the only treatments necessary for rostral fractures of the mandible or maxilla that involve little bone. If a significant component of alveolar bone of the body of the mandible has been broken, with damage or exposure of permanent incisor tooth buds, the fragment should be reduced and wired in place. The wiring configuration for incisor teeth depends on the type of fracture. As a rule of thumb, wires should engage a minimum of two teeth, and a minimum of two loops should be used to secure a fracture fragment. Figure 11–1*A* and *B* shows two types of fractures and wiring configurations. A hypodermic needle can be used as a trocar to guide the wire through the interalveolar spaces (see Fig. 11–1*A*).

When large components of the body of the mandible or maxilla are involved, or when interdental fractures are unstable but not displaced, stabilization is achieved by staple-wiring the fragments through predrilled holes (Figs. 11–1*C, D,* and *E*). The mucosa is incised to seat the wire next to the bone, providing the best fit and stabilization of the fragments when the wire is tightened. The holes are drilled at an angle that provides a solid fixation, but without damage to the sublingual carunculae of the mandibular salivary glands adjacent to the frenulum of the tongue (see Fig. 11–1*E*). For large fragments, double-stranded wire can be used to provide extra strength. Excess wire is cut off, leaving 1 cm of twisted wire, which is bent over flush with the bone surface and covered by suturing the mucosa (see Fig. 11–1*E*).

Figure 11–1.





Bilateral interdental fractures with displacement are unstable and frequently require the support provided by external fixation. After debridement of the oral wound, the fracture is reduced as determined by correcting the incisor occlusion. Temporarily wiring maxillary and mandibular incisors together will maintain occlusion and may help to stabilize the body of the mandible for pin placement. Using aseptic technique, two parallel 1/4-inch-diameter positive-profile centrally threaded pins are placed through the body of the mandible rostral to the fracture, and two pins are placed through both horizontal rami caudal to the fracture (Fig. 11–2). Tooth roots should be avoided. To insert the pins, 1-cm or larger stab incisions are made in the skin and through the soft tissues down to bone at the pin sites. A 6.2-mm drill bit and centrally threaded tap are used to machine the pinholes and the pins are inserted with a pin chuck. Release incisions are made for the drill, tap, and pins to exit the opposite side. These entry and exit incisions provide soft tissue drainage, reducing inflammation at the pin-skin junction. Drilling and tapping reduce thermal necrosis and debris accumulation in the bone, subsequently reducing the incidence of bone infection. An alternative to the full-pin assembly is a half-pin assembly using positive-profile threaded pins.[h]

Final adjustments in fracture reduction are made, the K-E rods are fixed to all four pins on each side of the jaw 1 cm (a fingerbreadth) from the skin, and the excess pin lengths are cut off. As a substitute for the K-E apparatus, the connecting bar between the pins can be made using 3/4-inch or larger flexible tubing filled with acrylic.[i] We routinely use anesthetic gas scavenger hose.[j] The tubing is placed over the pins, positioned 1 cm from the skin, and then filled with the acrylic (see Fig. 11–2). Reduction of the fracture must be maintained until the acrylic has hardened and the pins are cut off next to the acrylic connecting bars. If possible, the gingival defect is sutured with a monofilament synthetic nonabsorbable material. Often, tissue is missing, and the wound can be only partially sutured. Sterile sponges are packed between the K-E rods and the skin at the pin-skin junctions. The external appliance can be covered with a bandage to help prevent entanglement during convalescence.

[h]Interface fixation half-pin, IMEX Veterinary, Inc., Longview, TX.

[i]Technovit, Jorgensen Laboratories, Inc., Loveland, CO.

[j]Scavenger hose, Owens and Minor, Indianapolis, IN.

Postoperative Management

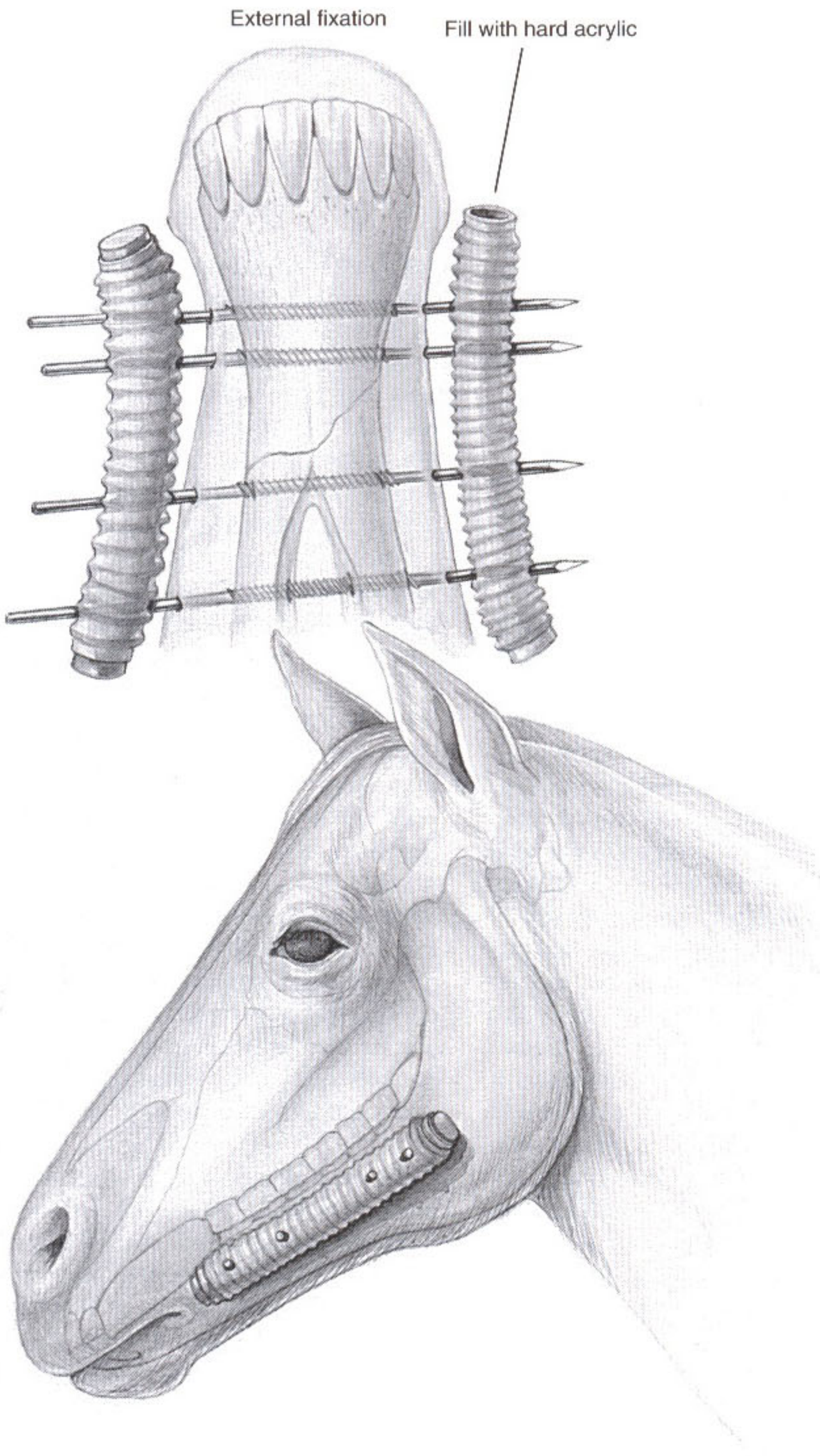
The sterile sponge packing at the pin-skin junctions is changed daily for 3 to 5 days. Packing is discontinued when granulation is present at the stab incisions. The patient should be confined and protected from additional injury for up to 30 days. Most of these patients return to eating standard feed immediately after surgery. Horses with severe damage may require a pelleted-feed gruel or may benefit from nasogastric intubation and hand feeding of slurry with a bilge pump for 7 to 14 days. Tetanus prophylaxis should be current. Nonsteroidal anti-inflammatory medication is indicated when the soft tissue swelling is severe. We do not practice routine flushing of the mouth after surgery. The value of a prolonged regimen of postoperative antibiotics is questionable. There is no evidence to suggest that antibiotics and mouth flushes prevent secondary infection.

Mandibular and maxillary fractures are usually open into the mouth, tooth alveoli are frequently involved, and fixation devices must be inserted through contaminated tissue. Localized infectious septic osteitis frequently develops. Such infections may become fistulous and drain under the chin. Fortunately, the bones of the head have a good blood supply, and healing progresses in spite of the infection. The wires or other hardware can be removed in 4 to 5 weeks, after which the infection resolves spontaneously. At the time of hardware removal, the fracture fissure usually is still evident radiographically, but fibrous healing and early callus provide sufficient stability. Persistent infection and drainage are signs of sequestration or alveolar periostitis, two common complications that require surgical correction. When the fracture is comminuted or cheek teeth are involved, the possibility of these complications and the need for a second surgery should be anticipated from the outset. Otherwise, if the temporomandibular joint is not involved, the prognosis for these fractures is excellent. Although malocclusion may persist in some horses, most fractures heal satisfactorily.

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Figure 11–2.



chapter 12

Dentigerous Cyst Excision

Dentigerous cysts, more appropriately termed *heterotopic polyodontia,* are uncommon but easily recognized defects in the horse.[1] They are also referred to as ear teeth, ear fistulas, temporal cysts, or temporal teratomas. By definition, they contain all or part of a tooth. These cysts are usually unilateral but may be bilateral. The ectopic tooth, which is attached to the temporal bone, has a secreting membrane that forms a fistulous tract, which leads to a sinus opening on the cranial border of the pinna. Embryologically, the ectopic tooth is tooth germ displaced toward the ear with the first branchial cleft. The cyst develops from ectodermal rests resulting from failure of the first branchial arch to close.[2] Strictly speaking, it is not a "fistula" but a defective closure. Except for the seromucous discharge and matting of hair, dentigerous cysts are usually inconspicuous. However, larger cysts with multiple enamel fragments and obvious swelling may occur.[3] Rarely, dentigerous cysts may form as a pedunculated mass or form intracranially.

Clinical recognition of dentigerous cysts is simple. Cysts are identifiable soon after birth, but it is not uncommon, because of the benign signs, for owners to delay attention for 2 to 3 years. The sinus opening on the pinna may be the only external evidence of the cyst. Sticky seromucous discharge may stain the ear region, and pressure over the base of the ear may increase the discharge.

A flexible lead probe is used to explore the sinus opening and to determine the depth and direction of the fistulous tract. It may be possible to sound the tooth component under the auricular muscles and scutiform cartilage, approximately 8 to 10 cm from the opening on the ear. Radiographs are not required for diagnosis but may help to identify the amount of tooth material present. Even though enamel is the most radiodense tissue in the body, small ectopic teeth may not be evident radiographically. Contrast material can be used to identify the size of the cyst cavity. Previous unsuccessful attempts at surgery will lead to infection, cicatrix formation, and alteration in the location of the fistulous tract and its opening.

Anesthesia, Positioning, and Surgical Preparation

Dentigerous cysts have been resected in standing horses using chemical restraint and local anesthesia. However, because of the variable size of the enamel components and the degree of attachment to the skull, the standing approach is not recommended. Continuous intravenous drip anesthesia may be satisfactory, but inhalation anesthesia provides the best control of the patient. The horse is positioned in lateral recumbency with the affected side up and the head positioned for easy access to the ear region. The surgeon should stand in the throatlatch region for the best orientation to the surgical anatomy. The ear and surrounding temporal region, extending beyond the midline, to the orbit rostrally, to the mid-masseter ventrally, and to the atlas caudally, is clipped and routinely prepared for surgery. It is not necessary to clip the mane or forelock, but a liberal area needs to be prepared because of the variable depth and direction of the dissection. Both the inner and outer surfaces of the ear should be clipped and scrubbed so that they can be manipulated intraoperatively. The external ear canal can be plugged with a sterile sponge and the fistulous tract irrigated with a dilute antiseptic solution as part of the preparation. Complete draping and an aseptic approach are recommended. Scar tissue and blemish are obviated by the dissection and removal of a closed fistulous tract and cyst. Perioperative antibiotics are commonly used but unnecessary.

Surgery

Successful surgical treatment entails complete removal of the aberrant tissues and preservation of the auricular muscles (Fig. 12–1*A*). Careful probing of the fistulous tract, combined with deep palpation at the base of the ear, helps to establish the required length and direction of incision and the depth and extent of dissection (Fig. 12–1*B*). The sinus opening is incised free and the neck of the cyst sealed with a ligature. The fistulous tract and cyst membrane are distinct, reasonably thick tissues facilitating identification and removal. Some residual fluid accumulation and distention aids dissection and removal of the closed cyst (Fig. 12–1*C*). The dissection plane should stay close to the cyst membrane to minimize hemorrhage and the chances of damage to the auricular muscles. The anterior auricular artery and auriculopalpebral nerve are readily avoided in this fashion. The tissues in the involved region of the head are vascular. Capillary oozing during surgery is best controlled by suction and electrocoagulation. The individual auricular muscles are not readily identifiable during surgery. They are ribbon-like structures that are camouflaged by the fascial components of the aberrant cystic membrane and the bleeding. The cyst should not be opened. Spillage of the contents causes contamination of the incision site, and the resultant cellulitis could endanger auricular function, prolong healing, and increase scarring.

The dental component may be small and easily levered from the temporal bone with a chisel or gouge (Fig. 12–1*D*), or the tooth may be molar-like with a complete alveolus. A considerable part of the temporal bone may be enamel-like in consistency, requiring forceful chiseling with risk to the cranium. We have encountered one case in which a Hall drill[a] and a bur were necessary to remove enamel deeply imbedded in temporal bone. However, to leave residual enamel will result in surgical failure with refistulization of the wound. Auricular muscles and deep fascia are approximated with 3–0 polydioxanone[b] simple interrupted sutures. Skin closure is routine. Drains or removable packs are unnecessary.

Postoperative Management

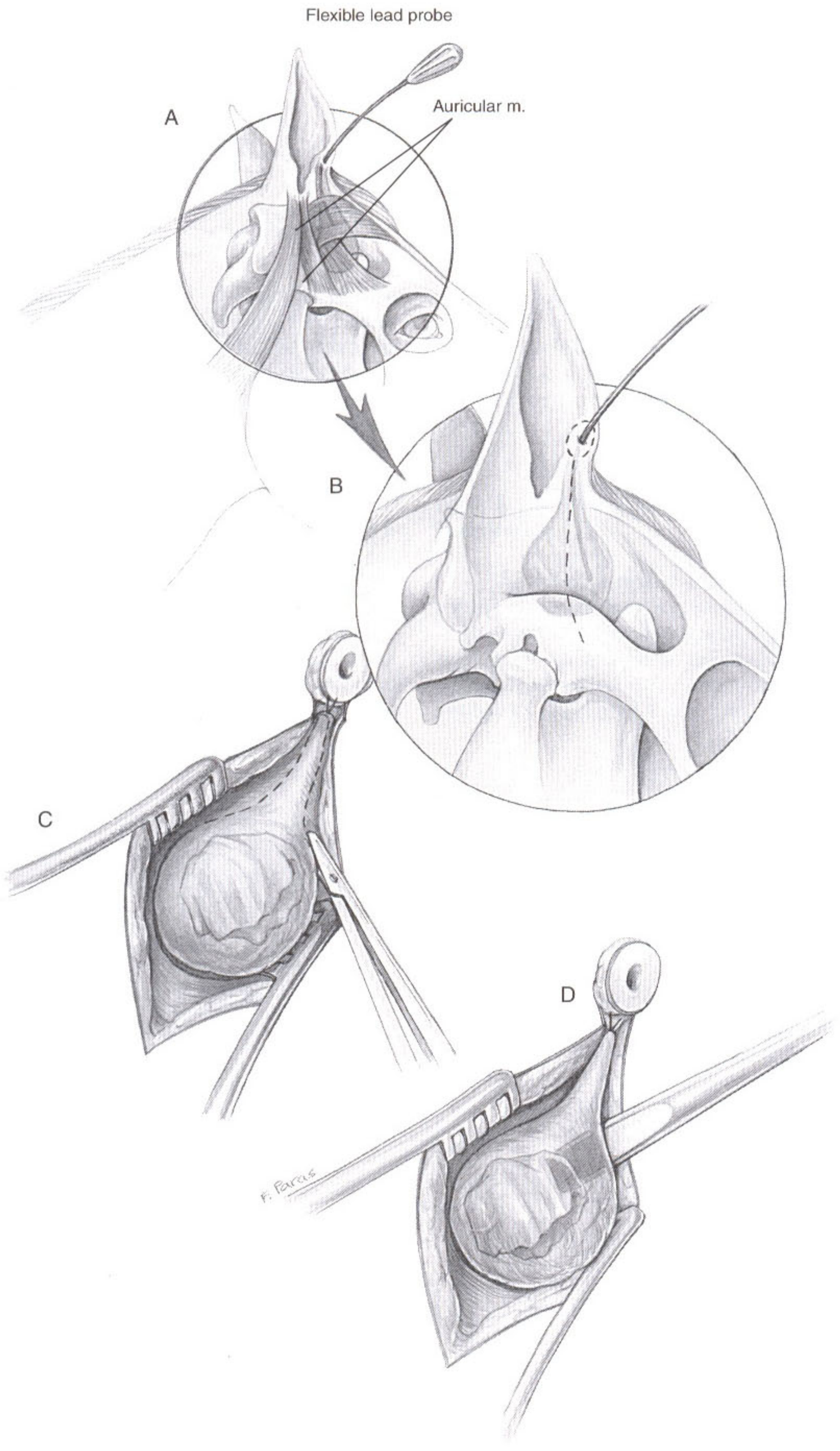
Postoperatively, the horse will protect the ear in a deviated position for 2 to 3 days but will move it immediately after recovery from anesthesia—evidence that auricular function is intact. Nonsteroidal anti-inflammatory drugs are useful if forceful chiseling has been used to remove the tooth. Provided closed dissection has been accomplished, primary healing can be expected. Convalescence is rapid, and recovery is complete and without blemish.

[a]Hall surgical micro 100 drill, Zimmer, Inc., Warsaw, IN.
[b]PDS II, Ethicon, Inc., Somerville, NJ.

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Figure 12–1.



chapter 13

Modified Forssell's Operation for Cribbing

Cribbing, or crib biting, is a common vice in which horses grasp a solid object with their upper incisors, contract the ventral neck muscles, arch their necks, retract the larynx, and pull backward. Horses often swallow air during this maneuver, and these horses have been called windsuckers.[1] Cribbing seems to be more frequent in horses confined to stables. Nonsurgical treatment to control cribbing is effective in many horses. The primary method of nonsurgical treatment has been the use of a cribbing strap. Surgery is indicated when nonsurgical treatment fails and when owners decline to use nonsurgical treatment.

The classic Forssell's operation is performed by myectomy of the sternothyrohyoideus, omohyoideus, and sternomandibularis muscles. Forssell's operation leaves the horse with a noticeable defect on the ventral aspect of the neck. By comparison, the modified Forssell's operation for the treatment of cribbing consists of myectomy of the sternothyrohyoideus and omohyoideus muscles and neurectomy of the ventral branches of the spinal accessory nerves.[2] The modified operation is easier to perform and leaves a less objectionable blemish.[2]

Anesthesia, Positioning, and Surgical Preparation

The horse is anesthetized and placed in dorsal recumbency. The hair is clipped from the rostral aspect of the mandibles to the caudal one third of the neck and laterally just dorsal to the jugular veins. The skin is surgically prepared in a routine manner. Prophylactic antibiotics are started 1 hour before surgery.

Surgery

A 30-cm ventral midline incision is made from the level of the vertical rami of the mandibles extending caudally (Fig. 13–1*A*). Bleeding should be well controlled by hemostats and electrocautery to prevent staining of the tissues with blood, thus making the identification of dissection planes and the spinal accessory nerves more difficult. The edges of the incised skin are retracted laterally to expose the sternohyoideus, omohyoideus, and sternomandibularis muscles.

The sternomandibularis muscle on one side of the neck is separated from the omohyoideus muscle with Metzenbaum scissors, and the medial and dorsal aspect of the muscle is exposed. The muscle is rolled laterally, and the ventral branch of the spinal accessory nerve is located beneath the epimysium. The nerve enters the sternomandibularis muscle approximately 5 cm caudal to the musculotendinous junction on the dorsal aspect. The nerve is difficult to see but can be felt with an index finger in a slight groove as it enters the muscle. The nerve is elevated from the muscle by blunt dissection with the index finger or with a hemostat (Fig. 13–1*B*). Pinching the nerve with hemostat forceps causes contraction of the sternomandibularis muscle, confirming isolation of the correct nerve. A 10- to 12-cm section of the nerve is removed, and the same procedure is performed on the opposite side of the neck. The omohyoideus and sternohyoideus muscles are freed from the larynx by isolating them with a curved instrument and then transecting them (Fig. 13–1*C*). At this level, their muscle fibers have blended together, making them appear as one muscle belly. The fascial attachments to the linguofacial veins and thyroid glands at the cranial aspect of the incision are freed. The muscles are then peeled (retracted) caudally toward the caudal end of the skin incision. The omohyoid muscles are transected obliquely in the lateral aspects of the incision, and the sternohyoideus muscles are transected transversely at the caudal aspect of the incision, removing a 30-cm section of the muscle bellies. The sternothyroid muscles are elevated from the trachea and removed for the length of the incision (Fig. 13–1*D*). A ¾-inch Penrose drain[a] is inserted into the wound and exited through stab incisions at both ends of the surgical field. The drain should not exit through the primary skin incision.

The subcutaneous tissues are closed with a simple continuous suture pattern using size 0 monofilament synthetic absorbable suture material, and the skin is closed with a continuous or interrupted suture pattern or with stainless steel staples. A stent bandage should be sutured over the incision to provide protection and reduce hematoma or seroma formation (Fig. 13–1*E*).

[a]Latex Penrose tubing, Sherwood Davis & Geck, St. Louis, MO.

Postoperative Management

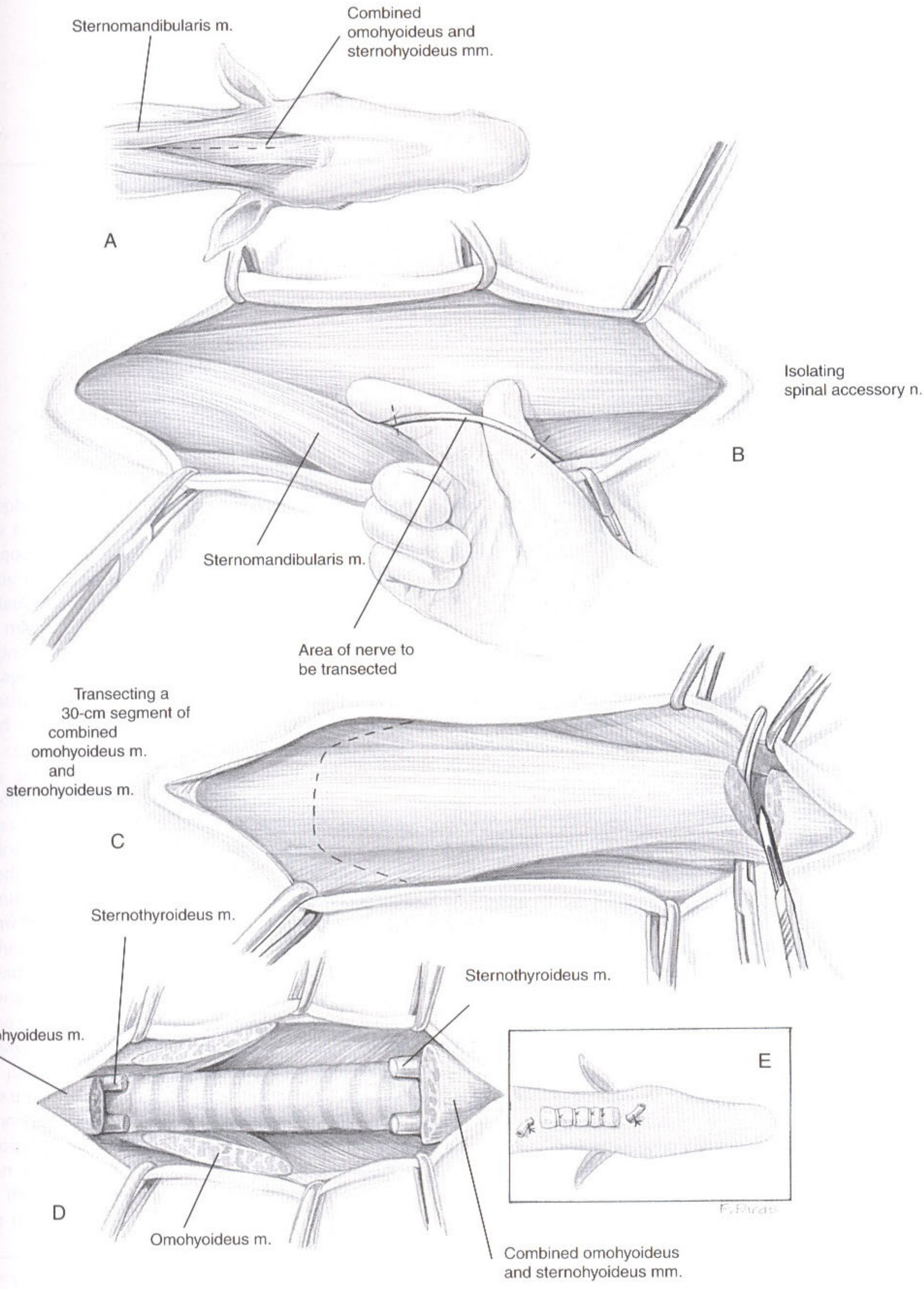
The horse should be confined to a stall for 2 weeks. The stent bandage should be removed by day 3 or earlier if it becomes wet or soiled. The Penrose drain can be removed in 4 to 6 days and skin sutures in 10 days. Exercise can resume after 3 weeks. Hematomas or seromas may form if the Penrose drain is not effective. They should be left alone to resolve spontaneously. Drainage of hematomas or seromas, when necessary, should not be done in the first 10 days after surgery because tissue inflammation may result in recurrence. Antibiotics may be administered until the drain is removed. Infection and dehiscence of the surgical wound are possible but occur infrequently.

The modified Forssell's operation results in a better cosmetic appearance after surgery than the original Forssell's operation, in which sections of the sternomandibularis muscles were excised. In 35 horses that underwent the modified Forrsell's operation, 57% had complete remission, 31% had improvement, and 12% had no improvement.[2] In another study of 103 horses that had the modified Forssell's operation, 50% had good results after surgery, 19% improved, and 31% relapsed.[3] By comparison, the same study reported the results of the Forssell's operation in another group of 103 horses as being good in 89% of horses, with relapse in 11%.[3]

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Figure 13–1.


Sternomandibularis m.
Combined omohyoideus and sternohyoideus mm.
A
Isolating spinal accessory n.
B
Sternomandibularis m.
Area of nerve to be transected
Transecting a 30-cm segment of combined omohyoideus m. and sternohyoideus m.
C
Sternothyroideus m.
Sternothyroideus m.
Sternohyoideus m.
D
Omohyoideus m.
E
Combined omohyoideus and sternohyoideus mm.

Gastrointestinal Surgery

chapter 14

Esophagotomy

Esophageal obstruction, or "choke," is the most common esophageal disease in horses. Obstruction is most frequently caused by impacted feed but may be caused by ingestion of carrots, apples, beets, and foreign materials such as wood chips.[1] Poor dentition and gluttony may predispose horses to esophageal obstruction. Aspiration pneumonia often occurs as a sequela to esophageal obstruction.[2] The clinical signs of esophageal obstruction include dysphagia, regurgitation of food and water, excessive salivation, repeated swallowing, coughing, extension of the head and neck, retching, and agitation.[2, 3] Diagnosis is made on the basis of clinical signs, physical examination, the inability to pass a nasogastric tube into the stomach, esophageal endoscopy, and esophageal radiography.

Medical treatment for esophageal obstruction with feed is initiated by sedation of the horse with xylazine[a] or detomidine[b] to relax the esophagus and lower the horse's head. Impacted feed material is lavaged with warm water pumped through a nasogastric tube positioned next to the mass within the esophagus. Water should be pumped in and out of the tube. Gentle external massage of the esophagus, when the mass is in the cervical part, may help to break up the mass. When initial treatment is unsuccessful, the horse may be muzzled to prevent food and water intake for 8 to 12 hours. Intravenous administration of oxytocin at 0.11 to 0.22 U/kg can assist resolution of obstructions by further relaxing the esophagus.[4] Lavage is repeated if the obstruction has not resolved while the horse is muzzled. Horses that are dehydrated and have electrolyte imbalances from loss of saliva should be treated with intravenous fluids until the obstruction is relieved, and then oral fluids can be given.

Most horses with esophageal obstructions caused by feed impactions can be successfully treated nonsurgically. Surgery is indicated when feed impactions do not respond to medical therapy and when foreign bodies or solid objects are the cause of the choke. Surgery is preferable to repeated trauma to the esophagus with a nasogastric tube. Esophagotomy is recommended only for the cervical part of the esophagus. Fortunately, this part constitutes more than 50% of the entire length of the esophagus, and esophageal obstruction often occurs in this section.

Anesthesia, Positioning, and Surgical Preparation

Esophagotomy can be performed on the standing horse using sedation and instillation of local anesthetic or after induction of general anesthesia. General anesthesia is preferred and is particularly helpful if primary closure of the esophagus is anticipated. Lavage of impacted feed via a nasogastric tube sometimes is successful with the horse anesthetized even though the technique was ineffective with the horse standing. This may be due to relaxation of the esophagus, improved restraint of the horse, and the ability to use larger tubes for lavage. If lavage fails, surgery can proceed. Esophagotomy on the anesthetized horse is described. The esophagotomy technique is identical on the standing horse.

[a]Rompun, Miles Inc., Shawnee Mission, KS.
[b]Dormosedan, Pfizer Inc., New York, NY.

Before surgery, broad-spectrum antibiotics should be administered intravenously. The hair on the ventral surface of the neck is removed with clippers, and a nasogastric tube is passed in the esophagus to the level of the obstruction. This will facilitate identification of the esophagus during surgery. The horse is anesthetized and placed in dorsal recumbency with the head and neck extended, the skin is surgically prepared, and the site is draped.

Self-retaining retractors will improve exposure of the esophagus. Pediatric Balfour abdominal retractors[c] have been advocated because they are atraumatic to the tissues.[2] Weitlaner, Gelpi, or other self-retaining retractors that are more traumatic than Balfour retractors may be used with caution. When self-retaining retractors are not available, an assistant can maintain exposure of the esophagus by retraction with Sauerbruch, malleable, or other flat blade atraumatic retractors. Surgical suction is advised, particularly if fluid and saliva are present in the esophagus proximal to the obstruction.

Surgery

The approach to the esophagus for removal of most obstructions can be made on the ventral midline. An 8- to 10-cm-long incision is made through the skin and subcutaneous tissues directly over the area of the obstruction (Fig. 14–1*A*).[2] The incision is extended through the paired sternothyrohyoid and omohyoid muscles on the midline to expose the ventral surface of the trachea. The trachea is retracted to the right, and, with careful, sharp dissection using Metzenbaum scissors, the fascia on the left side of the trachea is separated to expose the esophagus. The carotid sheath should be gently retracted laterally. Self-retaining retractors are placed in the wound to aid exposure. Extensive elevation of the esophagus from its surrounding adventitia with damage to small esophageal vessels should be avoided.[2] The esophagus is isolated from the surgical field with moist sponges to reduce contamination. A 5-cm longitudinal incision through muscle layers, submucosa, and mucosa of the esophagus is made with a scalpel blade. When possible, the incision into the esophagus should be made just distal to the obstruction in an area of normal esophagus (Fig. 14–1*B*). The edges of the incised mucosa can be stabilized with Allis tissue forceps or thumb forceps during removal of the obstructing material. Sponge forceps or other suitable grasping forceps can be used to remove the obstruction. This often requires multiple insertions of the forceps into the esophagus. Solid foreign bodies that will not move require incision into the esophagus directly over the foreign body. During removal of the obstruction, suction should be used to minimize spillage of saliva and small feed particles.

Incisions into normal esophagus can be closed. A simple continuous suture pattern using size 3–0 polypropylene[d] suture material with the knots tied within the lumen of the esophagus is placed in the mucosal-submucosal layer. These two layers are tightly bound and appear as a single distinct layer within the muscular tube. Nonabsorbable suture material is used to provide long-term suture strength to the esophageal incision, which must heal in the presence of contamination and constant motion. The muscular layer is closed with simple interrupted sutures using size 3–0 polypropylene or polydioxanone[e] material (Fig. 14–1*C*). A perforated silicone drain[f] is placed next to the esophagus, and the end is tunneled subcutaneously to the ventral midline at a point 4 to 6 cm caudal to the skin incision. The end is brought out of the wound through a small stab incision and secured to the skin. The sternothyrohyoideus and omohyoideus muscles and the subcutaneous tissues are each apposed with size 2–0 polydioxanone suture material using simple interrupted suture patterns. Skin is closed routinely with an interrupted pattern. After closure of the wound, constant suction is maintained on the drain with a 600-ml vacuum bottle[g] for 48 hours to remove serum and blood and to provide a means for early detection of saliva leakage.

When the incision must be made through devitalized esophagus, closure is not recommended.[2] Instead, an esophagostomy tube is placed directly into the esophagus through the incision. A flexible, clean, Silastic or polyethylene nasogastric tube with a 12- to 18-mm outside diameter is suitable. See Chapter 15 for details about placing, securing, and maintaining esophagostomy tubes.

To approach the esophagus just behind the ramus of the mandible or just in front of the thoracic inlet, a left ventrolateral approach is used. The approach for cranial esophagotomy is made just below the jugular vein where it divides into the maxillary and linguofacial veins. Dissection is carried around the lateral aspect of the larynx and the trachea to the esophagus, which is positioned dorsal to these structures. The caudal esophageal approach is also made ventral to the left jugular vein, and dissection is carried underneath the vein in a dorsal and medial direction through the cervical fascia to expose the esophagus.

[c]Balfour pediatric abdominal retractor, Baxter Healthcare Corp., Round Lake, IL.

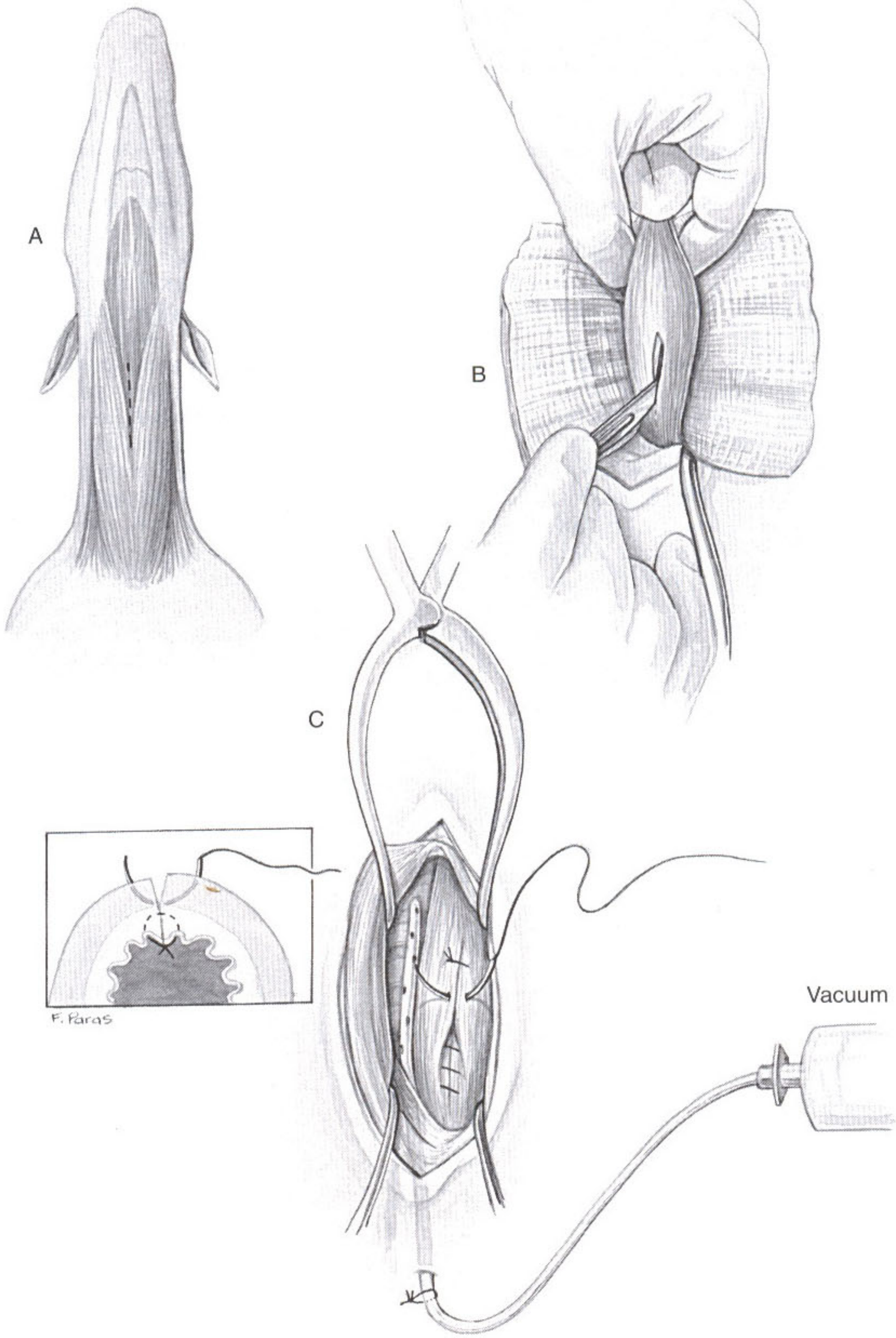
[d]Prolene, Ethicon, Inc., Somerville, NJ.

[e]PDS II, Ethicon, Inc., Somerville, NJ.

[f]Jackson-Pratt hubless silicon flat drain, Baxter Healthcare Corp., Round Lake, IL.

[g]Wound drainage system, DePuy, Warsaw, IN.

Figure 14–1.



Postoperative Management

Broad-spectrum antibiotics should be continued for 3 days, or longer if aspiration pneumonia is present. A bronchoalveolar or transtracheal wash with culture of the fluid for bacteria and subsequent antimicrobial sensitivity testing is indicated when the pneumonia does not resolve with the initial treatment. Nonsteroidal anti-inflammatory drugs are indicated as a part of the postoperative management of these cases.[2]

Food and water are withheld for 48 hours after surgery when the esophageal incision is closed. Intravenous fluid therapy is used to maintain hydration and electrolyte balance. Small quantities of complete feed pellets mixed in water to form a slurry are fed five to six times per day from 2 to 10 days after surgery, after which time feeding of moistened complete feed pellets or wet high-quality hay can begin.[2]

The drain can be removed at 48 hours when no saliva is leaking from the esophagus. If very small amounts of saliva are produced, the drain may be left in place for 3 or 4 days to remove the saliva continuously. The vacuum on the drain must be maintained. Some incisions with small amounts of salivary leakage will heal without dehiscence when saliva is removed.[2] Massive amounts of saliva leakage indicate dehiscence of the esophageal closure. In such cases, the drain is removed immediately, the skin and muscle layers are opened to allow ventral drainage, the tissues are lavaged, and the wound is left to heal by second intention.

Re-examination of the esophageal lumen with an endoscope for evaluation of healing can be done 10 days after surgery and then every 2 weeks until healing is complete.[2] Food impactions can result in circumferential mucosal damage with subsequent esophageal stricture and reobstruction of the esophagus. Esophageal lumen diameter is smallest 30 days after surgery and increases to near normal by 60 days.[5] For horses with circumferential mucosal lesions, a soft diet made from soaked complete feed pellets should be given for up to 60 days.[5]

Complications

Many esophagotomy incisions involving normal esophageal tissues that are sutured will heal with few or no complications.[2] Incisions that dehisce can be allowed to heal by second intention. In some horses, an esophagostomy tube can be placed into the esophagus at the point of dehiscence or closer to the stomach through a second incision. Loss of saliva can cause hyponatremic, hypochloremic metabolic alkalosis, which can be managed by providing sodium chloride in the diet. Laryngeal hemiplegia resulting from damage to the recurrent laryngeal nerve may occur when manipulations are rough or postoperative swelling and inflammation is marked. Besides aspiration pneumonia and reobstruction, complications related to the primary esophageal disease include esophageal ulceration, pleuritis, laryngeal hemiplegia, Horner's syndrome, periesophageal infection, and esophageal fistulization.[1]

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chapter 15

Cervical Esophagostomy

The primary indication for cervical esophagostomy is to provide a feeding tube portal for horses requiring prolonged extraoral administration of nutrients.[1–3] Cervical esophagostomy is an alternative to indwelling nasogastric intubation and should be considered when extraoral feeding will be necessary for more than 1 week. Tube feeding via esophagostomy bypasses the nasal passages, pharynx, and cranial esophagus. This spares the nasal and oral mucosa from pressure necrosis caused by indwelling nasogastric tubes. Cervical esophagostomy is also indicated to nourish and hydrate horses with severe diseases of the mouth, oropharynx, and cranial esophagus that prevent prehension and deglutition and to rest the cranial esophagus after esophageal surgery.

Cervical esophagostomy can be performed with the horse standing using local anesthesia or with the horse anesthetized. Surgery is usually performed at the level of the fourth or fifth cervical vertebra. At this level, the esophagus can be approached by a ventral or ventrolateral incision.[2, 3] Both approaches are suitable. We generally use the ventrolateral approach because it is more direct and may allow better access to the esophagus with less tissue dissection (Fig. 15–1*A*). This approach avoids the ventral cervical neck muscles, which are thicker in the caudal neck than more cranially.[2] The ventrolateral approach permits the feeding tube to exit the wound without impingement on the trachea.[2]

Anesthesia, Positioning, and Surgical Preparation

A smooth, clean polyvinyl chloride, polyethylene, or Silastic nasogastric tube with a 12- to 18-mm outside diameter is used for the feeding tube. Larger tubes are less likely to plug with feed. We select the largest tube that will easily pass through the esophagus. We prefer that the end of the tube is fenestrated to reduce chances of plugging. For standing surgery the horse is sedated and restrained in stocks, when available. A nasogastric tube is passed to the stomach and secured to aid identification of the esophagus during surgery. Surgery is performed on the side of the neck where the nasogastric tube can be palpated at the level of the fifth cervical vertebra. This is usually on the left side. The usual location of surgery is caudal to the midpoint of the neck. Esophageal injuries should be avoided, and the surgery site may have to be closer to the thoracic inlet. A liberal area centered over the jugular furrow and extending to the opposite jugular furrow and midway up the side of the neck is clipped, and the skin is surgically prepared. Fifteen to 20 ml of a local anesthetic[a] are instilled in a 6-cm line just ventral and parallel to the jugular vein into the subcutaneous tissues and into the deeper fascia between the jugular vein and the sternomandibularis muscle down to the esophagus.

[a]Carbocaine-V, Sterling Drug, Inc., McPherson, KS.

Surgery

A 6-cm skin incision is made parallel and just ventral to the jugular vein. The incision is extended through the subcutaneous tissues and the fascia between the vein and the sternomandibularis muscle (Fig. 15–1*B*). The jugular vein and brachiocephalicus muscle are retracted dorsally and outward, and the sternomandibularis muscle is retracted ventrally and axially to expose the deep fascia around the esophagus. In the middle of the neck, part of the omohyoideus muscle may need to be excised to expose the deep fascia. Esophagostomy closer to the thoracic inlet may require incision of the cutaneous colli muscle to expose the deep fascia. The deep fascia is carefully incised with scissors to expose the esophagus, which is readily identified by palpation of the indwelling nasogastric tube. Care should be taken to avoid damage to the carotid sheath and enclosed nerves. The sheath lies dorsal and slightly lateral to the esophagus.

Manipulation of the esophagus may induce swallowing and strong esophageal contractions. Contractions can be reduced by the topical application of lidocaine hydrochloride to the esophagus. The esophagus should be stabilized with a thumb and forefinger with minimal stripping of surrounding adventitia. A 3-cm ventral longitudinal incision through all layers of the esophagus, down to the indwelling nasogastric tube, is made with a scalpel (Fig. 15–1*C*). The indwelling nasogastric tube is removed to allow passage of the 12- to 18-mm feeding tube into the esophagus. Passage of the feeding tube can be facilitated by grasping and separating the edges of the cut mucosa with Allis tissue forceps (Fig. 15–1*D*). The largest feeding tube that can easily be passed into the esophagus should be selected. The surgeon should be careful not to pass the tube mistakenly between the inner elastic mucosal and submucosal layers and the outer muscular layer of the esophagus. The end of the esophagostomy tube should be placed into the stomach to reduce the chances of postoperative dislodgement of the tube.[4] The feeding tube is secured by butterfly tape bandages placed around the tube and sutured to the skin of the neck (Fig. 15–1*E*). An elastic adhesive tape bandage can be placed around the neck to secure the tube further and to protect the neck, but the incision should not be covered by the bandage in a way that will inhibit drainage.

Postoperative Management

Leakage of saliva around the feeding tube is expected. The skin of the neck should be cleaned as necessary and coated with petroleum jelly or other suitable skin protectant. The tube should be capped between feedings and flushed frequently to reduce obstruction with dried feed. We leave a column of water in the tube after each flushing. Obstructed tubes should be opened with rigorous warm-water flushes. A probang should be used only if necessary. Feeding tubes should not be removed from the esophagus because they are difficult to reinsert. However, reinsertion becomes easier after a granulation tissue stoma has developed in 7 to 10 days.

Horses should be fed a slurry made from complete pelleted feeds and water at the rate of 7 g of feed/kg body weight three times per day.[4] The surgeon should ensure that maintenance levels of water (60–80 ml/kg/day) are given each day with the feed. Salt should be added to the diet of horses with excessive leakage of saliva to replace sodium and chloride loss.

The esophagostomy tube should be kept in place for a minimum of 7 days to permit granulation tissue to form a stoma between the esophagus and skin. A longer period is recommended and will be necessary when the underlying disease requiring esophageal feeding resolves slowly. We have used esophageal tubes for as long as 60 days.

After the esophagostomy tube is removed, a mash or wet leafy hay can be fed. The stoma will heal spontaneously by second intention.[2] A traction diverticulum will result but is of little clinical significance.[3, 4]

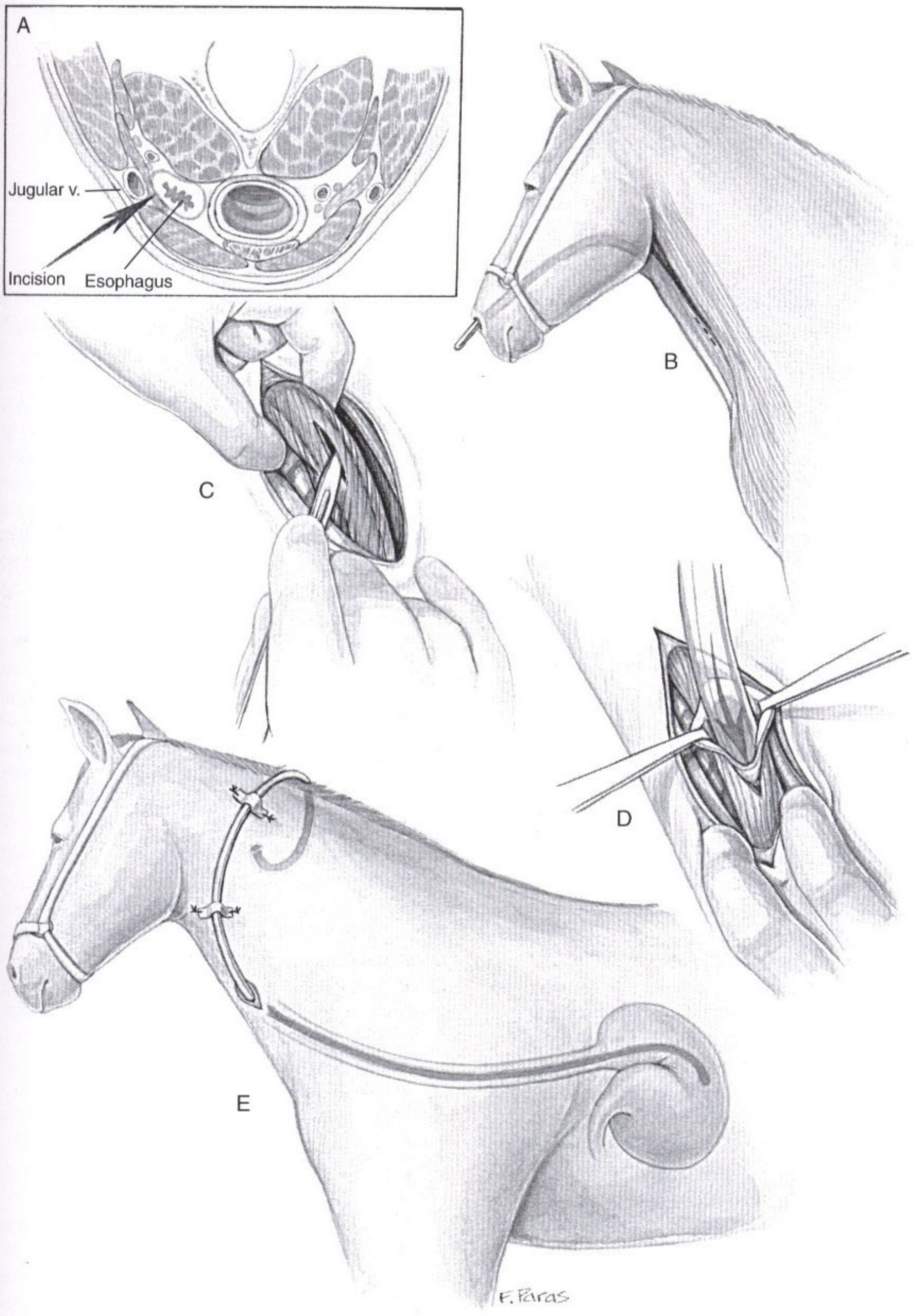
Complications

Dislodgement of the feeding tube can be a problem. Replacement of dislodged tubes can be difficult and may result in trauma to the esophagus and other structures in the immediate area. Rarely, infection in the neck will dissect to the thorax and mediastinum and cause death.[4] Laryngeal hemiplegia from damage to the nearby recurrent laryngeal nerve is possible.[4] Other complications such as swelling around the stoma, reflux of food from the stomach around the tube, and obstruction of the feeding tube usually are not serious.

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Figure 15–1.



chapter 16

Ventral Midline Celiotomy and Abdominal Exploration

The ventral midline celiotomy is the most common and useful approach to the equine abdomen. This approach provides good exposure to the abdominal contents and allows palpation, manipulation, or visualization of all the abdominal viscera. The ventral midline celiotomy is most commonly used for abdominal exploration in horses exhibiting colic, but it may also be used for cesarean section, ovariectomy, resection of infected umbilical cord remnants, repair of ruptured bladders in foals, and repair of lacerations of the rectum. The ventral midline approach provides greater exposure of the abdominal organs than any other approach. The incision can be made rapidly, avoids major vessels and nerves, and can be positioned cranially or caudally on the abdomen, depending on the viscera to be exposed. The incision can extend from the xiphoid to the pubis in female horses or to the prepuce in male horses. Closure can be rapid and is technically easy.

Closure of a ventral midline celiotomy must be secure to withstand recovery from anesthesia, the weight of the viscera in the standing horse, and large stresses occurring during movement, defecation, urination, and coughing. The linea alba is the main structure responsible for secure closure. The linea is a tough, dense, fibrous raphe extending from the xiphoid cartilage to the prepubic tendon. The thickness of the linea alba decreases from about 1 cm near the umbilicus to about 3 mm near the xiphoid. The breaking strength of the linea alba is greater near the umbilicus than near more cranial sections.[1] Proper-sized suture material and proper placement of the suture bites provide a secure closure of the linea alba. The optimum tissue bite size for adult horses is 15 mm from the edge of the linea alba.[1] Suture bites should be placed approximately 1 cm apart.[2]

Suture materials used for closure of the linea alba should be very strong. Most surgeons use synthetic absorbable suture materials for closure of the linea alba. Size 3 polyglactin 910[a] and size 2 polyglycolic acid[b] are the strongest available synthetic absorbable suture materials out of the package. Size 2 polydioxanone[c] is not as strong out of the package, but because of delayed absorption, it loses strength more slowly in the tissues than polyglactin 910 or polyglycolic acid and is stronger at 14 days and beyond.[3] The synthetic absorbable suture materials can be used in simple interrupted, simple continuous, or far-near-near-far (FNNF) suture patterns. The continuous pattern is usually placed in three to four sections.

The synthetic nonabsorbable monofilament suture materials also have been used to close the linea alba.[2] Polypropylene[d] and nylon[e] are weaker initially than the synthetic absorbable sutures. They should not be placed in a continuous pattern because of the difficulty in removing them if persistent infection and suture sinuses occur. These sutures offer no advantages over the synthetic absorbable materials. Although stainless steel is extremely strong and nonreactive in the tissues, it is difficult to handle and rarely used for primary closure of the equine linea alba. The braided polyester nonabsorbable suture materials are available in up to size 5 and are extremely strong, but they are associated with a greater incidence of suture sinus formation in infected wounds and are not recommended to close the linea alba.

The FNNF suture pattern has been recommended for closure of the linea alba in very large horses that place extreme stress on the linea alba.[2] This pattern and the similar near-far-far-near (NFFN) pattern produce a stronger closure than the simple continuous or simple interrupted suture pattern. However, the NFFN pattern has been associated with an increased prevalence of postoperative wound infection.[4] We do not believe the FNNF and NFFN patterns are interchangeable. We recommend the FNNF pattern in order to place the suture knots to one side of the incision and to place tension when pulling up the double loop on the outside (far) loop of the suture material.

[a]Vicryl, Ethicon, Inc., Somerville, NJ.
[b]Dexon II, Davis & Geck, Inc., American Cyanamid Co., Manati, PR.
[c]PDS, Ethicon, Inc., Somerville, NJ.
[d]Prolene, Ethicon, Inc., Somerville, NJ.
[e]Ethilon, Ethicon, Inc., Somerville, NJ.

The horse has a very long and complex gastrointestinal tract with highly mobile sections of bowel that can become displaced, twisted, incarcerated, strangulated, and obstructed in numerous ways. The abdominal cavity of horses with colic should be explored using a systematic approach when the cause of the colic is not readily apparent.[2] Random palpation and exteriorization of bowel can lead to confusion and frustration. Using the cecum as a reference point and with knowledge of the location of the ileocecal fold, cecocolic fold, and duodenocolic fold, the bands and sacculations of the colon, and the anatomy of the blood supply, the operator can explore the gastrointestinal tract systematically and thoroughly. The directions of twists and displacements and, most importantly, the direction for corrections of these problems will be more readily apparent.

Anesthesia, Positioning, and Surgical Preparation

Ventral midline celiotomy is performed with the horse anesthetized and positioned in dorsal recumbency. The hair on the ventral abdomen is removed from 10 cm cranial to the xiphoid process back to the pubis and laterally to just outside the folds of the flanks. In male horses, the penis can be catheterized and tied to one side with a snare made out of gauze, or it can be kept in the prepuce with a gauze pack secured by sutures or towel clamps in the external preputial orifice. A catheter should be used when urogenital surgery is anticipated. We prefer to pack the prepuce on most male horses undergoing abdominal exploration for treatment of colic. A standard surgical preparation of the ventral abdomen is performed. The draping system should provide a water-impervious barrier because contamination from bowel contents is common during surgery for colic. A complete description of draping is given in Chapter 3.

Surgery

Ventral Midline Incision

For exploratory laparotomy in an adult horse, a 30- to 35-cm-long incision is made through the skin and subcutaneous tissues starting at the umbilicus and extending craniad. Care is taken to stay on midline (Fig. 16–1*A*). In young animals, the incision length is proportionally shorter in relation to the body size. Bleeding is controlled before incision of the linea alba. The incision is extended through the linea alba starting at the umbilicus, where the midline is easy to identify. A small incision is made through the linea to allow two fingers to be inserted to the inside of the body wall (Fig. 16–1*B*). The fingers protect the underlying viscera from accidental perforation and identify the location of the linea alba as the incision is extended craniad. Bloated horses present the greatest risk. Extreme caution should be used when incising the linea alba so as not to perforate the peritoneum and any underlying, greatly distended loops of bowel that may be pushed tightly against the peritoneum. Once the linea alba has been incised, the retroperitoneal fat and peritoneum can be perforated with both index fingers and bluntly separated the length of the incision (Fig. 16–1*C*). Alternatively, the falciform ligament can be grasped with a thumb forceps, tented up, and incised with blunt-blunt scissors. Again, extreme caution should be used not to perforate distended bowel. Before abdominal exploration or other intra-abdominal procedures are performed, the incised edges of the body wall can be protected with a wound protector 11-inch ring drape.[f] This drape reduces trauma and contamination of the body wall incision. For horses in which bowel will be opened by enterotomy or for resection and anastomosis, we routinely place an adhesive plastic U-shaped drape[g] over the ring drape to prevent contamination of the underlying drapes and to provide a smooth, nonirritating surface for the intestines.

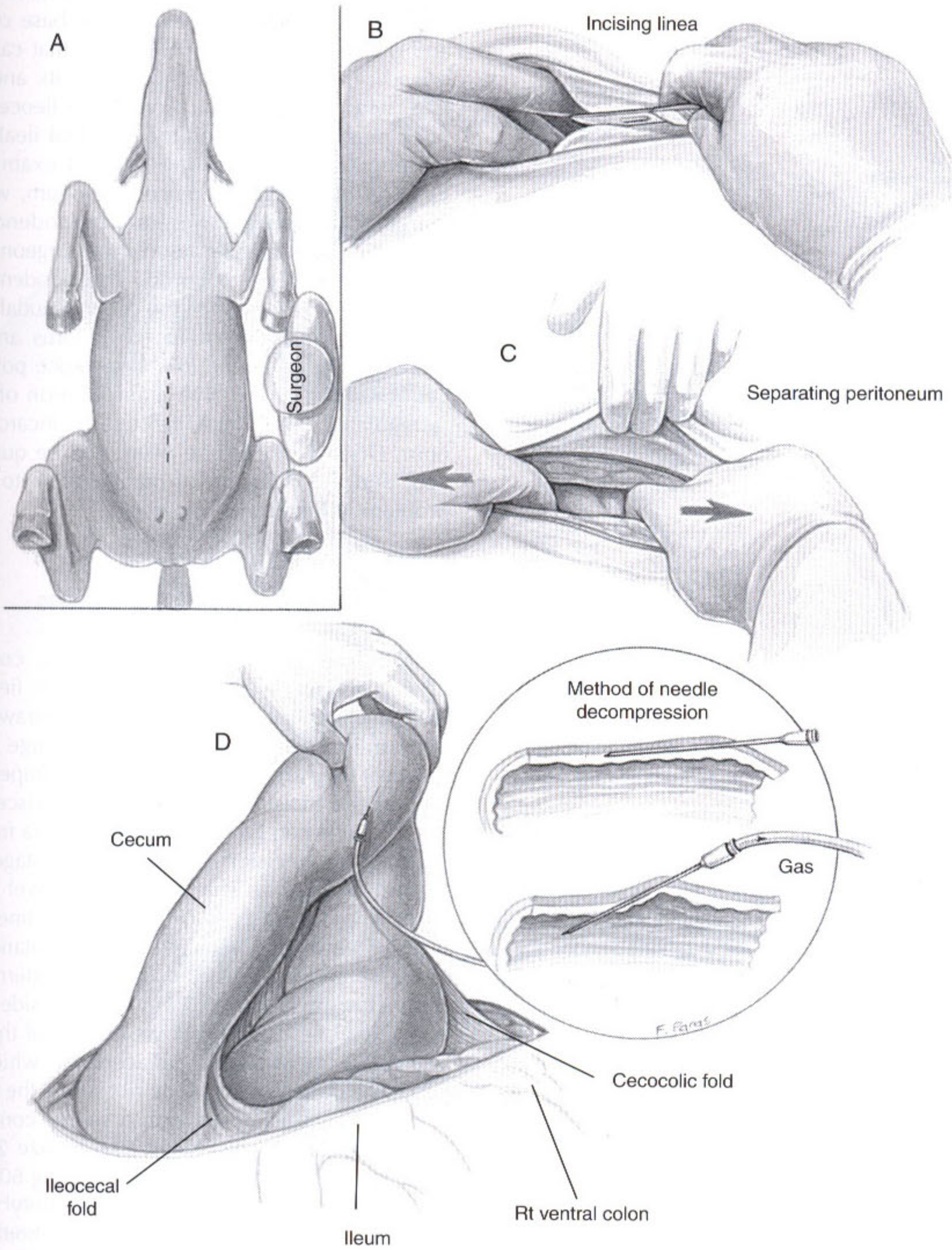
Exploration of the Abdomen

Ingesta free within the abdomen indicates rupture of bowel, and further surgery is unwarranted. Distended jejunum, cecum, or large colon will often push out of the incision in horses with intestinal strangulation or obstruction. Decompression of the distended cecum or colon facilitates further exploration of the abdomen and exteriorization and repositioning of bowel. Gas can be removed from the cecum or colon using a 14-gauge needle attached to a rubber tube with the free end passed out of the surgical field. Suction on the tube will hasten removal of the gas. Gas or fluid in the jejunum can be massaged into the cecum when no obstruction is present. Needles should be inserted into the bowel nearly parallel to the surface so the tip of the needle passes subserosally for approximately 1 cm (Fig. 16–1*D*). The site of puncture can be oversewn if necessary to prevent leakage once the needle is withdrawn.

[f]Vi-Drape wound protector, 11-inch ring drape, Becton Dickinson AcuteCare Division, Franklin Lakes, NJ.

[g]Poly U-Drape, Boundary Healthcare, Columbus, MS.

Figure 16–1.



The cause of the colic may be readily apparent. If not, deeper exploration within the abdominal cavity is warranted. The cecum is used as the starting point for further exploration.[2] The ileum, jejunum, and duodenum are traced orally, and the large and small colon are traced aborally from the cecum (Fig. 16–2). The initial direction for tracing the bowel depends on the distribution of distended bowel. When the cecum and colons are distended, the exploration should proceed aborally. When stomach and small bowel are distended, the exploration first proceeds orally.

Normally the cecum is slightly to the right of the ventral midline incision and can be exteriorized by following the ventral cecal band to the apex, which is

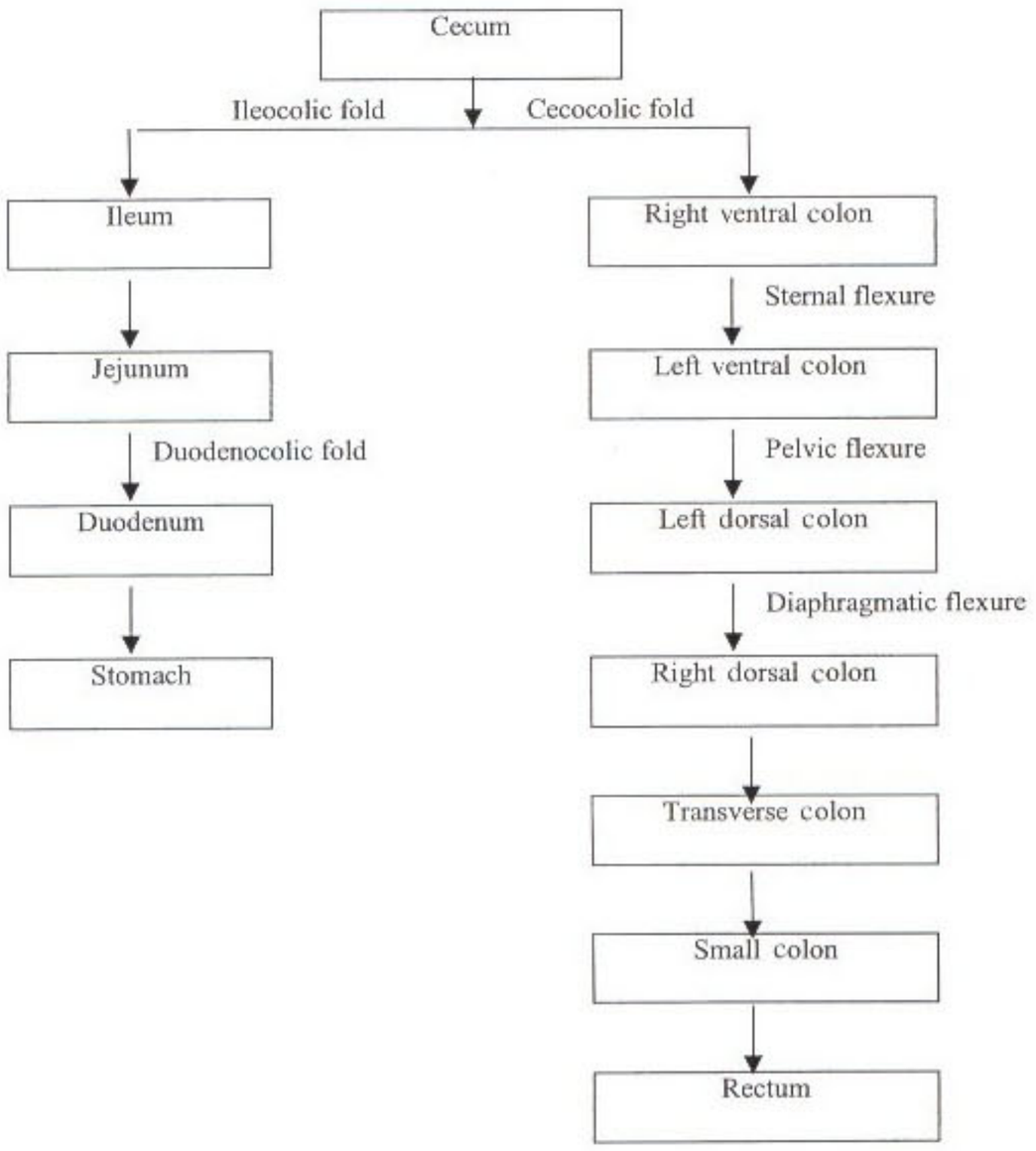


Figure 16–2.

Method of abdominal exploration using the cecum as the starting point.

grasped and pulled up and out of the incision. The cecum is checked for proper orientation using the cecal bands for reference. The cecocolic fold is continuous with the lateral band of the cecum and connects the cecum to the right ventral colon (see Fig. 16–1*D*). The free edge of the fold should be cranial and should be on the right lateral side of the cecum. Displacements of the colon or cecum may alter this position. The large colon can be examined by following the cecocolic fold to the right ventral colon and palpating the rest of the colon in an aboral direction to determine whether it is in a normal position and to detect obstructions, displacements, impactions, enteroliths, and other abnormalities. Palpation should terminate at the rectum. The left dorsal and ventral colons and most of the right dorsal and ventral colons usually can be exteriorized through an adequate incision when needed, but intraluminal gas must be removed first. We prefer to place the exteriorized colon along the left side of the horse on a colon tray.[h] This tray allows enterotomy or colon resection to be performed away from the ventral midline incision, facilitates continuous lavage of the bowel without having fluids enter the abdominal cavity, and allows a hose to be used for flushing water into the colons to assist removal of ingesta without massive contamination of the abdominal cavity.

Evaluation of the small intestine is initiated by retroverting the apex of the cecum backward to expose the dorsal longitudinal band. This band is continuous with the ileocecal fold, which can be followed to the ileum (see Fig. 16–1*D*). The surgeon's hand should pass unobstructed along the fold to the base of the ileum and orally to that part of the ileum that can be exteriorized. The ileum is identified by its antimesenteric fold, which is a continuation of the ileocecal fold, its thick muscular wall, and the marginal ileal artery. The jejunum is easily exteriorized and examined to the junction of the duodenum and jejunum, which is demarcated by the antimesenteric duodenocolic fold. Reaching this structure assures the surgeon that all the jejunum has been explored. The duodenum can be traced around the base of the cecum caudal to the great mesentery and forward to the pylorus and stomach. Using the ileum as the initial reference point will prevent much unproductive manipulation of displaced, strangulated, obstructed, twisted, or incarcerated jejunum. Disease oral to the ileum will be quickly identified, and the direction of manipulation to correct the problem will be more apparent.

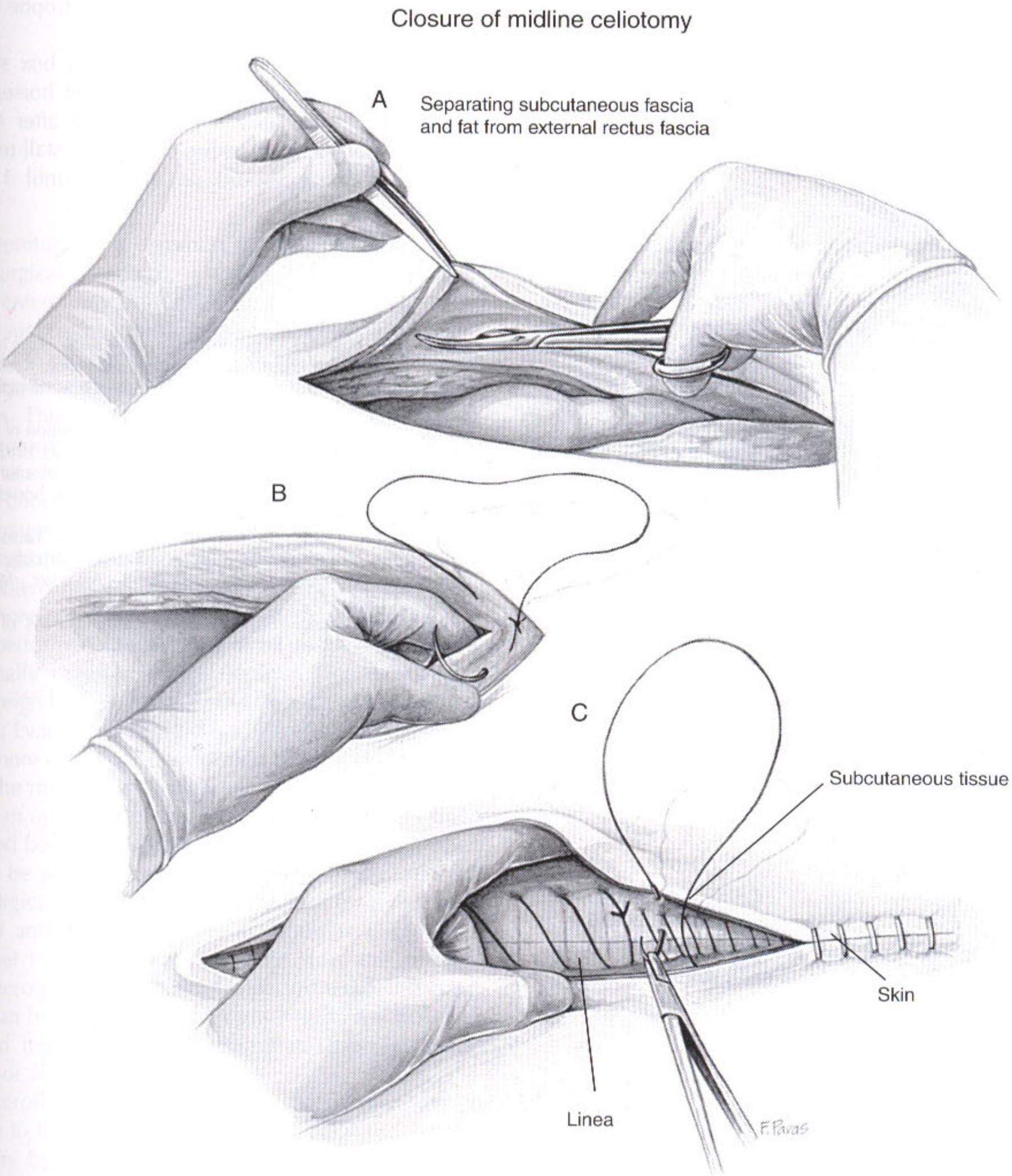
Closure of the Ventral Midline Incision

Before closure of the incision, contaminated drapes are removed from the surgical field, and the wound-protecting ring drape is withdrawn from the abdomen. The surgeons should change gloves and gowns if they are contaminated. New drapes are placed around the incision when needed. A visceral retainer[i] or wet towel can be used to keep viscera from protruding out of the incision during the initial stages of closure of the linea alba. The retainer or towel is removed when approximately two thirds of the linea is closed. Before suturing the linea alba, the subcutaneous fat and fascia should be dissected from the external fascia of the rectus muscle for 1.5 cm on each side of the incision (Fig. 16–3*A*). This allows closure of the linea alba without strangulation of adjacent fat, which has little suture-holding ability. We do not suture the peritoneum. The linea alba is closed with a simple continuous pattern using size 3 polyglactin 910 or size 2 polydioxanone suture material in horses weighing 600 kg or less. These materials have poor knot security and require five or six throws for each knot. Knots should be placed to one side of the incision so they are not directly on midline. This makes them easier to cover with subcutaneous tissues and less likely to protrude from the incision. The suture line should start beyond the end of the incision on the linea alba and finish beyond the opposite end. The suture bites should be 1.5 cm from the edges of incised linea alba and should not incorporate the retroperitoneal fat. The distance between suture bites is 1 cm (Fig. 16–3*B*). The suture strand should be pulled taut after each bite is taken to aid closure of the

[h]Colon tray, Kimzey, Inc., Woodland, CA.

[i]Viscera retainer, Jorgensen Laboratories, Inc., Loveland, CO.

Figure 16–3.



linea alba. However, the surgeon must avoid using the jaws of the needle holders to pull on the suture strand. This action will weaken the strand and predispose it to failure. The simple continuous pattern is interrupted and tied every 10 cm. A 30-cm-long incision would have three separate simple continuous lines in the linea alba. The linea alba may be under tension and difficult to appose after colic surgery. In such cases, one or two towel clamps can be used to hold the linea together during the initial stages of closure. For horses weighing greater than 600 kg, the suture material can be doubled or an interrupted FNNF suture pattern can be used.

Subcutaneous tissues are closed with a simple continuous pattern using size 0 synthetic absorbable suture material (Fig. 16–3*C*). The subcutaneous tissues are tacked to the rectus fascia every third or fourth bite to reduce dead space and postoperative seroma formation. All knots from closure of the linea alba should be covered. The skin is closed with a simple continuous pattern using nonabsorbable suture material or by using stainless steel skin staples. Skin staples can be placed rapidly and are associated with a low incisional infection rate. After closure of the skin, we place a plastic adhesive drape[i] over the incision to reduce contamination of the wound during recovery of the horse from anesthesia.

[i]Ioban 2 antimicrobial film, Animal Care Products, 3M Health Care, St. Paul, MN.

Postoperative Management

The adhesive drape is removed after the horse recovers from anesthesia. We do not routinely wrap the abdomen. Nonsteroidal anti-inflammatory drugs can be administered as needed to control pain and inflammation. Antibiotics are selected and administered for treatment of the primary problem. Skin sutures or staples should be removed between 7 and 10 days.

The abdominal incision should be observed daily for heat, swelling, edema, drainage, and pain. Ventral edema always forms but should be nonpainful and should resolve in 12 to 14 days. Painful and excessive edema, prolonged edema, or drainage suggests incisional infection. Other complications include incisional abscess, suture sinus formation, dehiscence, and hernia formation.[5] In one study, complications occurred in 37% of horses that underwent ventral midline celiotomy.[5] Complications were more common in horses undergoing ventral midline celiotomy for treatment of colic than of nonintestinal disease. Incisional drainage, if present, should be cultured for microbes. Draining incisions should be cleaned, and drainage should be assisted by removal of skin sutures or staples. Stitch abscesses and suture sinuses are treated by stitch removal. Postoperative hernias may form secondarily to incisional infection and should be surgically repaired in 4 to 6 months. Dehiscence is a catastrophe that may lead to euthanasia.

The horse should be rested in a box stall with daily hand walking for 4 weeks. Quiet horses can be turned out into a paddock or pasture after 4 weeks. Vigorous horses may require 6 weeks of stall rest before turnout. Training should not resume until 12 weeks after surgery.

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chapter 17

Enterotomy Techniques

Enterotomy is a common surgical procedure used during surgical treatment of horses with colic. Mastery of basic enterotomy principles and techniques is necessary for successful intestinal surgery. Enterotomies are performed to remove gas, fluid, ingesta, foreign bodies, enteroliths, fecaliths, and impactions from the lumen of intestines. The pelvic flexure is the most common site for enterotomy. Pelvic flexure enterotomy allows the surgeon to evacuate the dorsal and ventral large colons. There is concern that enterotomy at the pelvic flexure may damage the neural pacemaker at that location, which regulates retropulsion-propulsion of the colon.[1, 2] This problem has not been apparent to us clinically. Furthermore, complete resection of the pelvic flexure can be performed successfully in horses. Enterotomy is occasionally required in the jejunum for removal of fluid, foreign bodies, feed obstructions, and ascarid impactions. Evacuation of fluid and ingesta from the jejunum is more commonly performed by digital manipulation of the material into the cecum and by evacuation through an open end of diseased jejunum that has been transected before resection and anastomosis. The open end can be placed over the side of the horse and out of the surgical field to serve as a conduit for removal of the fluid and ingesta. After evacuation is completed, the bowel is resected and removed from the surgical field. Enterotomy of the cecum is performed at the apex, which can be pulled over the right side of the horse so fluid and ingesta do not contaminate the abdominal incision or abdominal cavity.

Enteroliths in the transverse colon may not be movable to the pelvic flexure for removal, and enterotomy may be needed in the dorsal colon. Enterotomy in the dorsal colon should be performed in a segment that can be exteriorized and isolated (packed off) with towels and drapes from the rest of the surgical field. When large amounts of fluid and ingesta are present in the colons, an enterotomy in the pelvic flexure to evacuate the contents before enterotomy in the dorsal colon to remove the enterolith is recommended. Indications for enterotomy of the small colon include removal of enteroliths, fecaliths, foreign bodies, and impactions.

Principles of Performing Enterotomies

Enterotomies should be performed in sections of bowel that can be exteriorized and isolated from the abdominal incision and abdominal cavity with moist towels and drapes. We prefer to use impervious drapes whenever possible. Plastic U drapes[a] with adhesive backing can be used to separate the enterotomy site from the rest of the surgical field. Copious lavage of the enterotomy site is recommended during evacuation of the bowel and during closure. Impervious drapes help prevent the fluids from contaminating sterile areas.

All enterotomies, except for those performed on the cecum, can be made on the antimesenteric side of the bowel. In the small colon, the enterotomy is performed through the antimesenteric band. Bursting wall tension of small colon enterotomies in the antimesenteric band is significantly stronger than for enterotomies performed adjacent to the band in the sacculations.[3] Enterotomy incisions should be oriented longitudinally on the bowel to reduce postoperative stricture of the bowel lumen. Short enterotomy incisions in the small-diameter jejunum of foals or ponies can be closed transversely. A longitudinal enterotomy incision in the cecal apex is made parallel to the cecal bands.

All enterotomies can be closed safely with a two-layer suture technique.[4] We prefer to use a simple continuous pattern with suture bites incorporating the full thickness of the incised edges for the first layer and a continuous Cushing pattern in the second layer. This technique can be performed quickly and results in minimal stricture of the lumen of the bowel when the surgeon is careful not to invert an excessive amount of tissue. We use polydioxanone[b] suture material for both layers of all enterotomies; however, other materials such as polyglactin 910[c] and polyglycolic acid[d] are acceptable.

After closure of the enterotomy incision, the bowel should be gently cleansed. The surgeon should remove all contaminated drapes and change contaminated gloves and gown before completing the surgical procedure.

[a]Poly U drape, Boundary Healthcare, Columbus, MS.
[b]PDS II, Ethicon, Inc., Somerville, NJ.
[c]Vicryl, Ethicon, Inc., Somerville, NJ.
[d]Dexon II, Davis & Geck, Inc., American Cyanamid Co., Manati, PR.

Surgery

Pelvic Flexure Enterotomy

The pelvic flexure is exteriorized and positioned to the left side of the abdomen preferably on a colon tray,[e] or caudal to the incision between the hind limbs. The colon tray is placed on the left side of the horse and tilted down to slope away from the abdomen. The pelvic flexure is the ventralmost aspect of the left colon when the colon is placed on a colon tray (Fig. 17–1*A*). Enterotomy at this site allows ready access to both the dorsal and ventral aspects of the great colon with minimal contamination of the rest of the colon or the abdominal incision. Fluids and ingesta flow away from the enterotomy site and into a large receptacle. An assistant is required to manipulate ingesta up and out of the abdominal portion of the colons when complete evacuation is desired. When available, a second assistant can stabilize the pelvic flexure during the enterotomy. All but 30 cm of the left colon is covered with moist drapes or plastic U drapes to prevent dessication and contamination during the procedure. A 10-cm-long enterotomy is made with a scalpel blade on the antimesenteric side of the pelvic flexure (see Fig. 17–1*A*). During evacuation of ingesta, copious lavage of the serosa of the colons with sterile saline is recommended. Irrigation of the lumina of the colon with water from a hose will hasten evacuation. An assistant can pass the hose up the lumina of the left ventral and left dorsal colons. The hose should be clean but need not be sterile. The water should be at body temperature. After cleansing, the enterotomy is closed with size 2–0 polydioxanone suture material in a simple continuous pattern. The suture line should be longer than the incision line. It should start in normal bowel and finish in normal bowel. The tail of the first knot is left long and grasped with hemostats to stabilize the bowel, and a temporary stay suture can be placed at the other end of the incision (Fig. 17–1*B*). Suture bites should be taken 5 mm apart and 3 mm from the edge of the incision. The mucosa tends to separate and retract away from the seromuscular layer, and the surgeon should be sure to incorporate it in each suture bite. The enterotomy site is cleansed after the first layer is completed. A continuous Cushing pattern using size 2–0 polydioxanone is placed as the second layer. The knots should be inverted. Bites should be 5 mm apart and 5 mm from the first suture line (Fig. 17–1*C*). The tail of the first knot can be left long and grasped with hemostats to provide stability, or the bowel can be held by an assistant (see Fig. 17–1*C*). As the Cushing pattern is being placed, tension should be maintained on the suture strand, causing inversion of the bowel. After both layers have been placed, the bowel is cleansed and fluid is squeezed under pressure into the pelvic flexure to check for leaks. Any sites of leakage should be oversewn with interrupted Lembert sutures. Enterotomy of the cecum, right ventral colon, right dorsal colon, and left dorsal colon is performed using the same two-layer method.

[e]Colon tray, Kimzey, Inc., Woodland, CA.

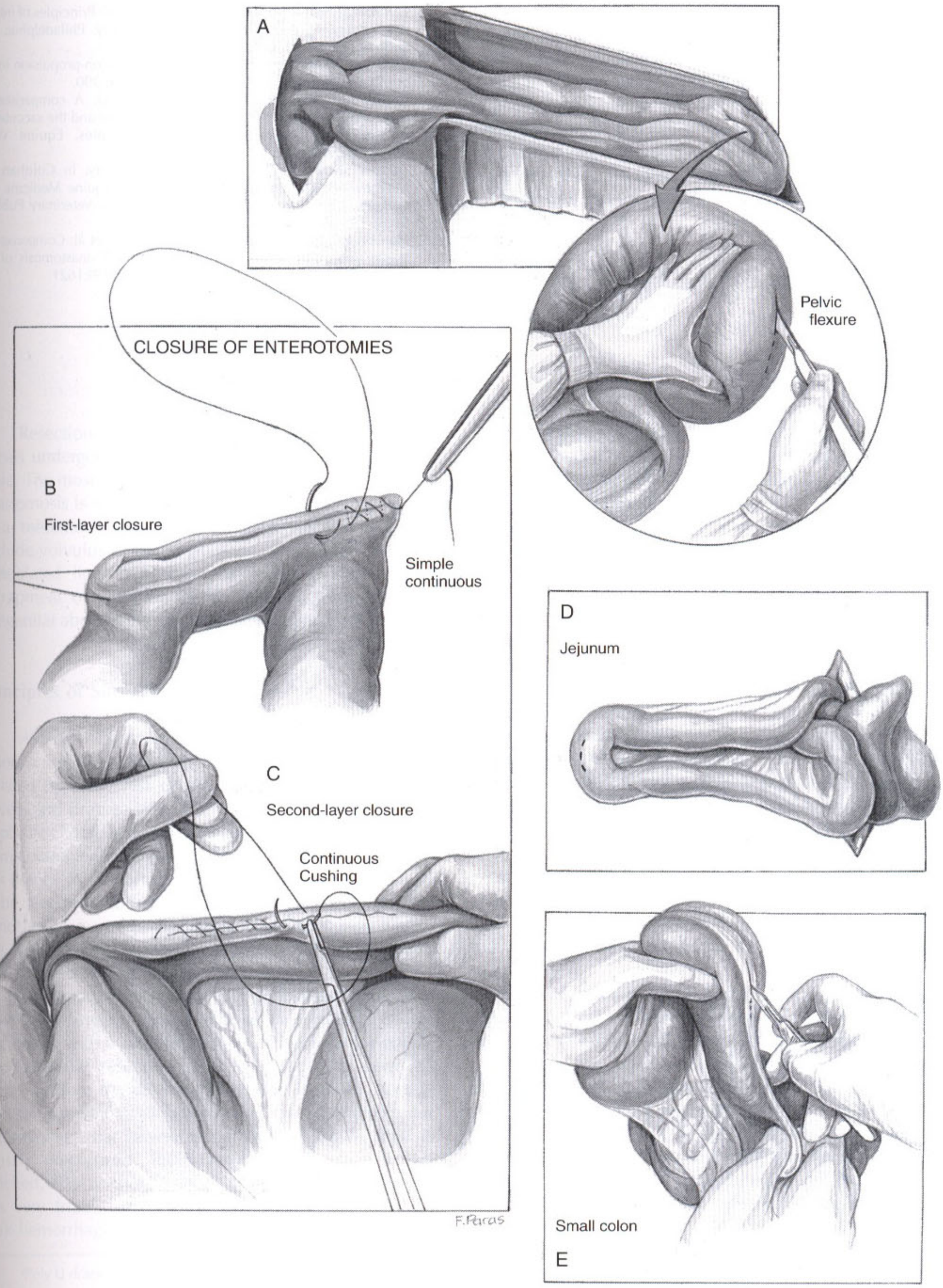
Enterotomy of the Jejunum

Enterotomy of the jejunum is performed in the same way as for the pelvic flexure, but the incision and suture patterns are on a smaller scale. If a localized object is to be removed from the jejunum, occlusal bowel clamps are placed on each side of the object, and the enterotomy site is isolated with drapes. Evacuation of fluid from a long segment of jejunum requires a loop of bowel to be pulled to one side of the abdomen. A 2.5-cm-long incision on the antimesenteric side of the bowel is made with a scalpel blade (Fig. 17–1*D*). This incision can be lengthened when necessary for removal of solid objects. After evacuation and cleansing, the jejunum is closed using a two-layer closure with size 2–0 polydioxanone. The first layer is a simple continuous full-thickness pattern through mucosa, submucosa, and the seromuscular layer. Suture bites are taken 5 mm apart and 3 mm from the incised edges. A continuous Cushing pattern with bites 5 mm apart and 2 mm from the first suture line completes the closure. Minimal inversion of the jejunum is important to prevent postoperative obstruction.

Small Colon Enterotomy

The site for the enterotomy should be exteriorized and isolated with impervious drapes. Fecaliths, enteroliths, and foreign bodies are often tightly wedged into the lumen of the small colon; and, not uncommonly, the bowel wall is bruised, discolored, hemorrhagic, and inflamed. Enterotomy at this location is not ideal. The enterotomy is preferably made in normal bowel just distal (aboral) to the obstructed site. A 10- to 15-cm-long longitudinal incision on the antimesenteric band is made; the length depends on the size of the object to be removed (Fig. 17–1*E*). The enterotomy incision is closed in two layers using size 0 polydioxanone suture material. The first layer is a simple continuous or simple interrupted pattern through the full thickness of the bowel wall with suture bites 5 mm apart and 3 mm from the incised edges of the colon. The second layer is composed of a continuous minimally inverting Cushing pattern with suture bites 5 mm apart and 2 mm from the first suture line. Some surgeons do not incorporate the mucosa in the first layer because it appears unnecessary for adequate healing.[5]

Figure 17–1.


A
Pelvic flexure
CLOSURE OF ENTEROTOMIES
B
First-layer closure
Simple continuous
C
Second-layer closure
Continuous Cushing
F.Paras
D
Jejunum
Small colon
E

Complications

Leakage of the enterotomy closure with subsequent local or diffuse peritonitis is an uncommon but potentially fatal complication. Adhesions to the enterotomy site may develop and cause recurrent colic. Rarely, mural abscesses at the enterotomy site may form. Swelling and obstruction at the site of the enterotomy are also possible. This complication is more apt to occur in the jejunum and, particularly, in the small colon where the luminal contents are dry and solid.

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chapter 18

End-to-End Anastomosis

Jejunal Resection and Anastomosis

Resection of diseased jejunum is often required in horses undergoing abdominal surgery for treatment of colic. The most common lesion requiring resection and anastomosis is strangulation–obstruction of the jejunum in a mesenteric rent.[1] Other causes of strangulation include volvulus of the mesentery, intussusception, pedunculated lipomas, adhesions, inguinal herniations, entrapment of jejunum in the epiploic foramen, and congenital abnormalities such as Meckel's diverticulum.

Principles of Surgery

After identification and correction of the strangulation-obstruction, the bowel to be resected should be isolated from the rest of the surgical field with moist towels and drapes. We prefer impervious drapes such as plastic U drapes[a] to prevent strike-through of bacteria from contaminated areas to clean areas. These impervious drapes can be used to encircle the section of bowel to be resected. During surgery, all exposed bowel that is not to be resected should be kept moist and warm. We routinely use a sterilized spray bottle filled with saline to keep bowel moist.

The anastomosis must be performed on viable bowel. The surgeon should remove all nonviable bowel and bowel with a high likelihood of becoming nonviable. Generally, resection of bowel should be done 25 cm away from the diseased segment. In many horses, clinical assessment of bowel may be satisfactory for determining what bowel is nonviable.[2] Bowel that is grossly discolored, lacks reflex contraction when pinched, has no pulsation in the mesenteric arteries, has very friable and easily torn mesentery, and has dark hemorrhagic mucosa should be resected. Not all nonviable bowel or bowel that will become nonviable has the gross changes that indicate that resection is necessary. A pink color, arterial pulsation, and contractions may be evident after correction of strangulating-obstructing lesions in bowel that will become nonviable. The delayed damage may be due to reperfusion injury, vascular thrombosis, or ongoing inflammation. Surface oximetry, fluorescein dye distribution, and Doppler flow probes have been used during surgery to predict viability of bowel. However, these methods of evaluating bowel blood flow are not always good indicators of viability of bowel in the postoperative period. The current recommendations are to evaluate the bowel grossly for viability and, when in doubt, resect the bowel when technically possible.[2] Resection should be performed near a major arterial supply. In humans, one of the most common causes of anastomotic failure is inadequate blood flow to the resected ends. The gas, fluid, and ingesta that often accumulate in the viable jejunum oral to the lesion should be removed before anastomosis. This facilitates management of postoperative ileus and decreases the chance that the swelling that forms at the anastomotic site will lead to an obstruction.

A leakproof, secure closure of the jejunum is necessary for success. The submucosa should be incorporated in the closure of the anastomosis. The two sections of bowel to be joined should not be under tension. Bowel must be carefully apposed on the mesenteric side, where accurate apposition of cut edges may be difficult. Mucosa should not evert through inverting suture patterns, because this may lead to leakage. All closures should be tight enough to prevent fluid leakage immediately after suturing. Mesenteric defects created by resection of the bowel should be closed.

There are limits to the amount of jejunum that can be removed with a successful outcome. In one

[a]Poly U drape with tape, Boundary Healthcare, Columbus, MS.

study, healthy ponies with resection of up to 40% of the jejunum were able to maintain body weight, whereas those ponies with 60% resection of the jejunum lost weight after surgery.[3] Our clinical experience with diseased horses indicates that resection of more than 40% of the total length of the small intestine is usually unsuccessful.

Surgery

The cause of the strangulation-obstruction is identified and corrected. The bowel to be resected is isolated from the surgical field, and the resection and anastomosis procedure is started by placing intestinal occlusion clamps (nos. 1 and 2 on Fig. 18–1*A*) adjacent to the diseased segment to confine ingesta and toxins to that segment. If not contained, the toxins can move into adjacent normal segments of bowel, where they will be absorbed and contribute to systemic deterioration of the horse.[4]

When removal of ingesta and fluids in the jejunum oral to the site of resection is not required, the surgery proceeds with the placement of occlusion and resection clamps. Ingesta and fluids are massaged away from the diseased segment 40 to 50 cm oral and aboral to the proposed sites of transection, and the bowel is occluded with noncrushing Glassman[b] intestinal forceps (nos. 3 and 4 on Fig. 18–1*A*). These forceps are closed gently to prevent passage of ingesta through the lumen of the bowel. Some surgeons prefer to encircle the bowel with a ¾-inch Penrose latex rubber drain[c] after making a small hole in the mesentery.[4] The drain is pulled tight enough to occlude the lumen of the bowel and is held with hemostats. These drains are effective and inexpensive but require repair of the mesenteric defect after removal. The resection site should be close to a jejunal arcuate artery to ensure a good blood supply. At the point of transection of the jejunum, which should be at least 25 cm from each end of the diseased segment, a small defect is made in the mesentery adjacent to the bowel, and intestinal resection clamps (nos. 5 and 6 on Fig. 18–1*A*) are placed at a 60° oblique angle to the longitudinal axis of the bowel so that the antimesenteric side of the bowel is shorter than the mesenteric side. This angle ensures good vascularity on the antimesenteric side and slightly enlarges the lumen of the anastomosis.[4] Any straight clamp that can be closed securely is suitable for this step because the bowel under the clamp will be discarded. We use straight Doyen[d] forceps. Mesenteric vessels supplying the segment of bowel to be resected are isolated with hemostats and tied off with triple ligatures of size 2–0 polydioxanone[e] suture material. The mesenteric vessels are ligated close to the jejunum when the mesentery is viable to provide ample length of mesentery for closure after the anastomosis is completed. However, when the mesentery is necrotic, all of the necrotic portion or as much as possible should be removed. Failure to do so will increase adhesion formation and may predispose to hemorrhage from necrotic mesenteric vessels. When all the vessels have been ligated, the bowel and mesentery can be excised with the resection clamps remaining attached to the discarded segment of bowel (see Fig. 18–1*A*).

When jejunum oral to the site of resection and anastomosis is distended and needs to be decompressed by the removal of accumulated fluids, ingesta, and toxins, a different sequence of clamping and resection is used. The two most aboral clamps (nos. 4 and 6) are placed on the bowel. The first clamp (no. 6) is placed at the intended site of resection at a 60° angle to the longitudinal axis. Ingesta is massaged aborally 15 to 20 cm, and the occlusal clamp (no. 4) is placed or a Penrose drain is used for occlusion. All of the mesenteric vessels are ligated as previously described. The bowel is transected adjacent and aboral to the resection clamp (no. 6) so that the clamp is left attached to the bowel to be discarded (Fig. 18–1*B*). The mesentery is transected. The oral end of the bowel to be removed is placed over the side of the abdomen and out of the surgical field to serve as a conduit for the removal of intestinal contents, which are digitally massaged out of the oral segment of jejunum. An unscrubbed assistant removes the resection clamp (no. 6) so ingesta will flow (see Fig. 18–1*B*). After decompression of the jejunum, the two most oral clamps (nos. 3 and 5) are positioned as previously described, and transection of the bowel is completed. The transected bowel is allowed to drop out of the surgical field into a receptacle.

[b]Glassman noncrushing intestinal clamp, Allegiance Healthcare Corp., V. Mueller, Deerfield, IL.

[c]Latex Penrose tubing, Sherwood Davis & Geck, St. Louis, MO.

[d]Doyer forceps, Allegiance Healthcare Corp., V. Mueller, Deerfield, IL.

[e]PDS II, Ethicon, Inc., Somerville, NJ.

Figure 18–1.

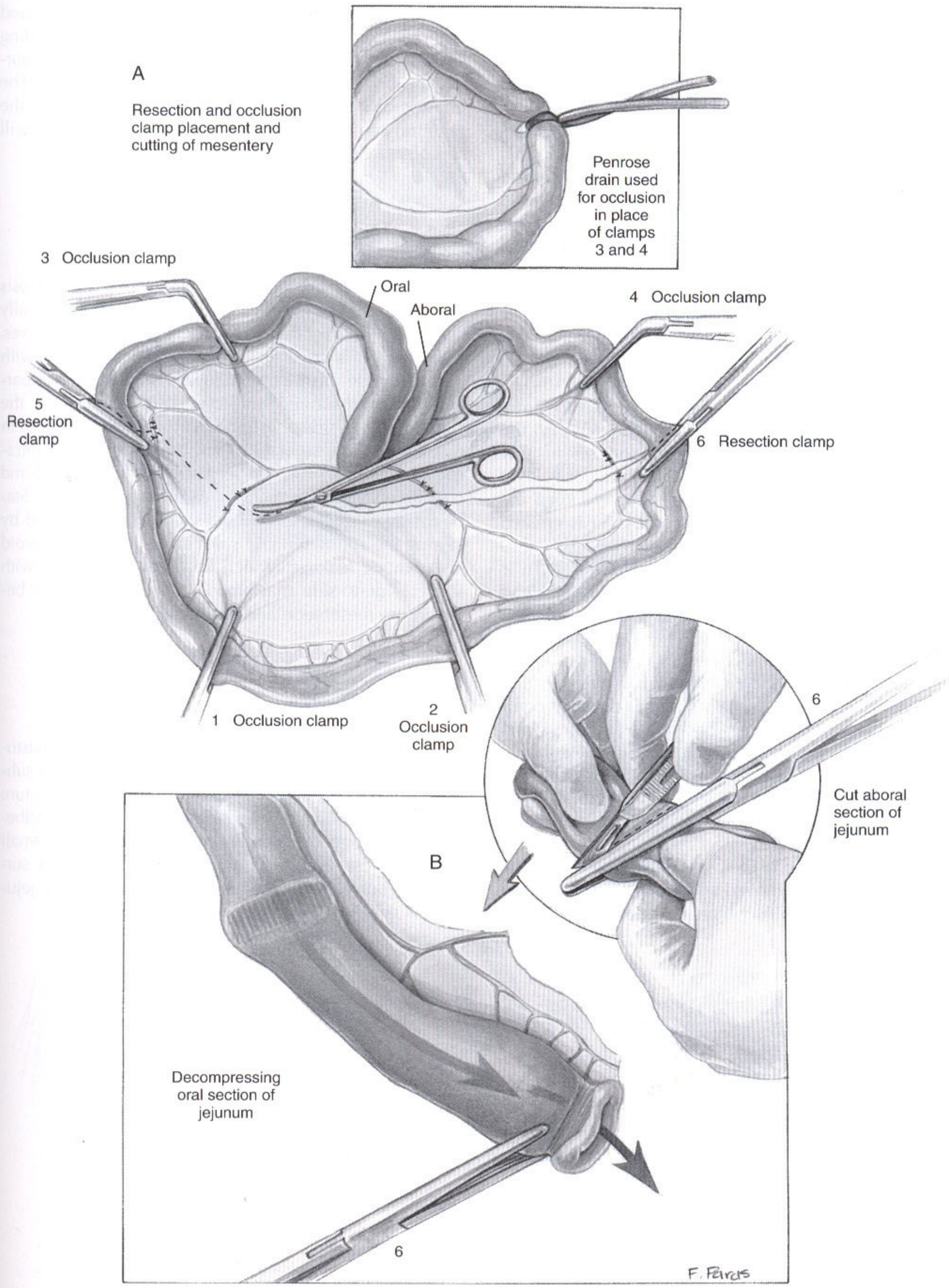


Illustration continued on page 101

After resection of the diseased segment, the two open ends of the jejunum are brought together and held with stay sutures in the mucosa at the mesenteric and antimesenteric sides, with the mesentery very slightly offset (Fig. 18–1*C*). The stay sutures are kept under slight tension parallel to the incisions to ensure that the two open ends have comparable diameters and are aligned correctly. Tension on the stay sutures reduces the chances of stricture of the bowel at the anastomotic site. They help to prevent a pursestring effect around the circumference of the bowel during closure. We anastomose the jejunum using a continuous two-layer inverting suture technique.[5] The mucosa is apposed with size 2–0 polydioxanone suture material in a simple continuous pattern. The first suture line is started at the mesenteric stay suture and ends at the antimesenteric stay suture (Fig. 18–1*D*). The bowel is turned over by 180° rotation, and the mucosa is opposed similarly on the opposite side to complete the first layer (Fig. 18–1*E*). Suture bites are placed 3 to 5 mm apart and 3 to 5 mm from the cut edge of the mucosa. The tails of the mucosal stay sutures are cut. A second set of stay sutures is placed to oppose the serosubmucosal layer of the jejunum, and slight tension is used to keep the lumen of the bowel open. The second layer is created by using a continuous Lembert pattern of size 2–0 polydioxanone (Fig. 18–1*F*). The Lembert pattern is placed in two lines, interrupted at the mesenteric and antimesenteric sides. The needle enters the serosa 5 mm from the incised edge of the bowel and exits at the junction of the serous and muscular layers, with only superficial penetration of the submucosa.[5] Penetration of the needle on the opposite side of the closure begins at the junction of the serous and muscular layers and exits the serosa 5 mm from the edge. Suture bites should be 4 to 5 mm apart (see Fig. 18–1*F*). This technique provides an adequate serosal seal with minimal inversion of the bowel and without disruption of the submucosal blood supply.

After completion of the two-layer anastomosis, the occlusal clamps are removed and fluid is massaged into the anastomotic section, which is squeezed to create intraluminal pressure. The anastomotic site is checked for patency and leakage. Any leaks are closed with interrupted Lembert sutures. The mesentery is closed with a simple continuous suture pattern while avoiding occlusion of or damage to mesenteric vessels that nourish the bowel at the anatomic site (Fig. 18–1*G*). The anastomosis site is gently cleaned and lavaged if the jejunum can be positioned so that the lavage fluids will run out of the surgical field.

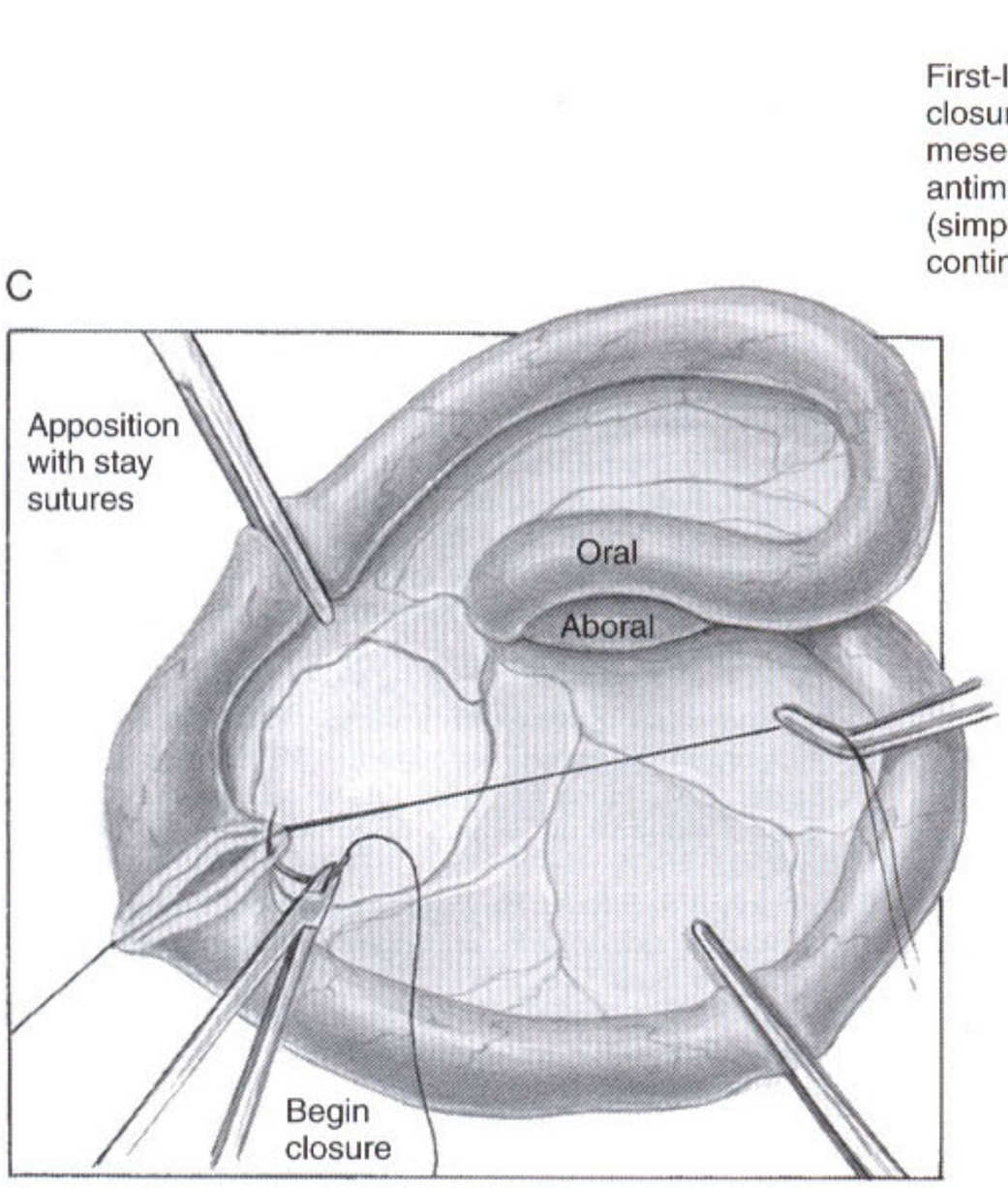
Other Methods of Jejunal Anastomosis

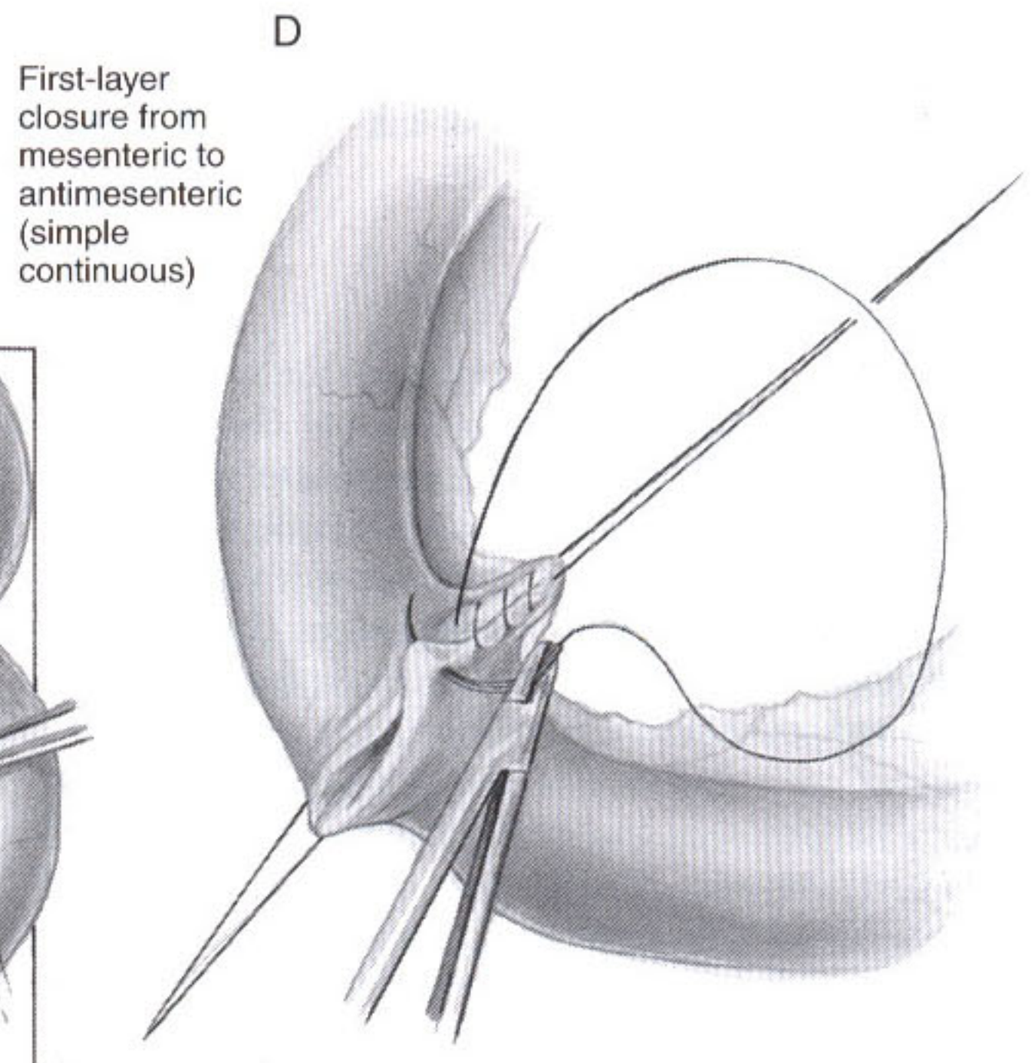
A hand-sutured two-layer side-to-side anastomosis can be successfully performed on jejunum but generally is not favored over the end-to-end technique. However, some surgeons prefer to anastomose the jejunum with a stapled side-to-side technique.[6,7] One study comparing the hand-sutured end-to-end anastomosis to the stapled side-to-side anastomosis found no differences in operating times, stomal areas, histopathology, or intra-abdominal adhesions between the two techniques and concluded that both techniques were acceptable.[6] Stapled side-to-side anastomoses should be performed by joining the antimesenteric sides of the jejunum to avoid anastomotic leakage, which has been associated with stapled side-to-side anastomoses performed halfway between the mesenteric and antimesenteric sides.[7]

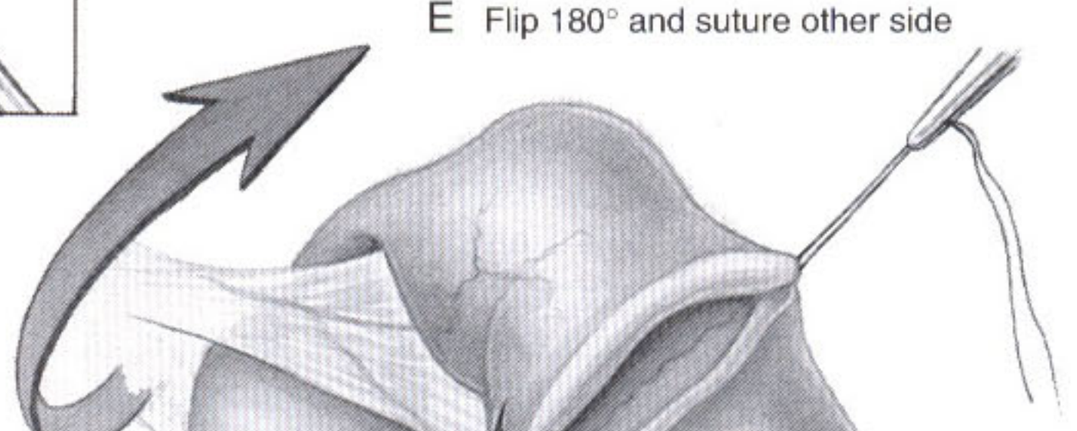
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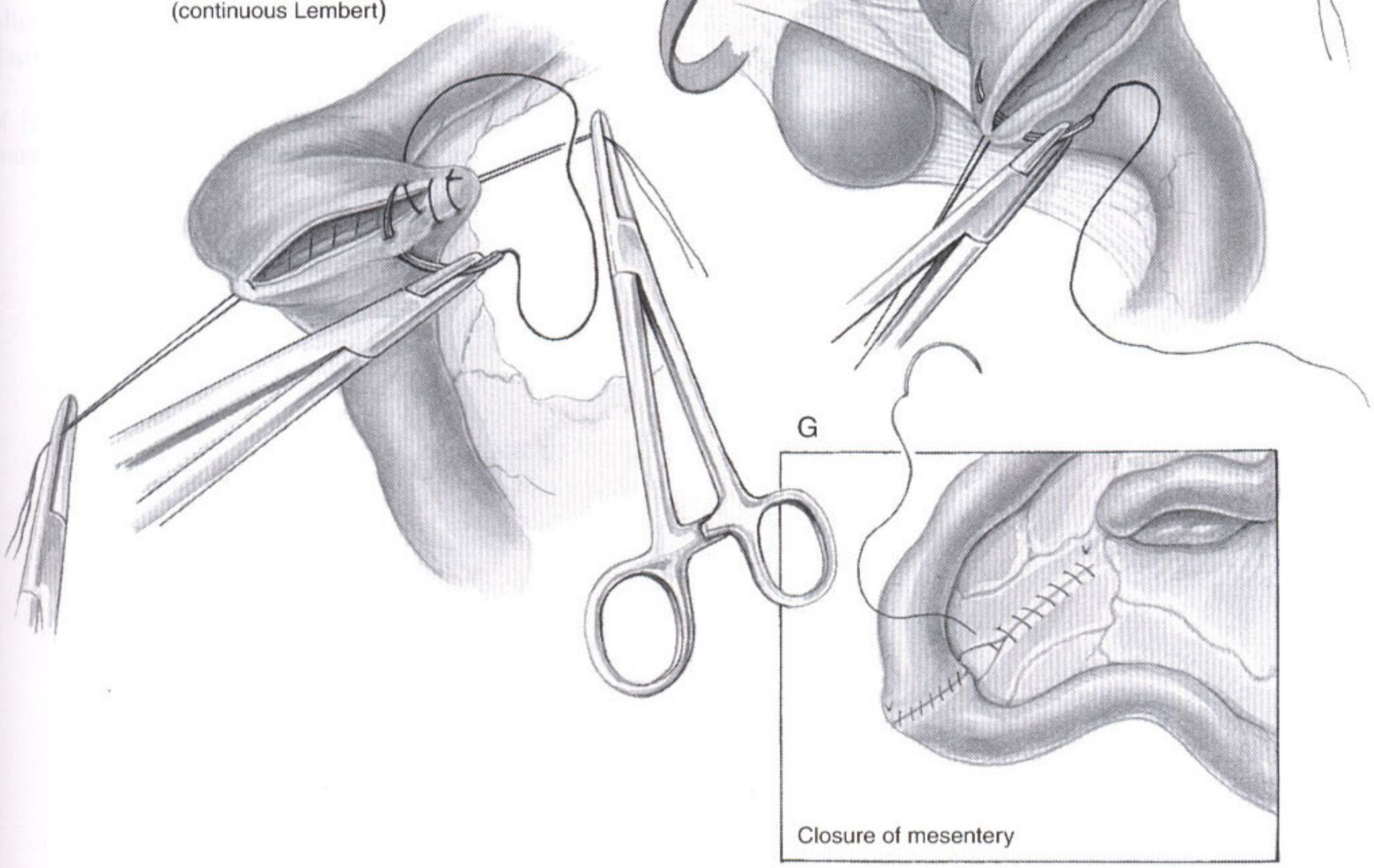
Complications after jejunal resection and anastomosis include leakage at the anastomotic site with subsequent local or diffuse peritonitis, adhesions, stricture at the anastomotic site, and postoperative ileus. Adhesions are the most common cause of death after small intestinal resection.[1] The prognosis for long-term survival for horses after resection and anastomosis of jejunum is guarded.

Figure 18–1. *Continued*









Small Colon Resection and Anastomosis

A two-layer inverting technique for small colon end-to-end anastomosis is similar to that described for the jejunum. Size 0 polydioxanone suture material is used. The first layer is sutured with a simple interrupted full-thickness pattern that excludes the mucosa. The second layer is closed with a continuous Cushing pattern interrupted at one half of the circumference of the bowel to reduce stricture formation.[8]

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chapter 19

Jejunocecal Anastomosis

Lesions requiring resection of the small intestine often involve the distal jejunum and ileum. Resection of the ileum can present the surgeon with some special problems and considerations. The blood supply to the ileum comes from one artery that courses parallel to the bowel. Damage to this artery will compromise blood flow to the ileum. Although jejunoileal anastomosis after resection of the distal jejunum and part of the ileum is feasible, it is not generally recommended.[1] The terminal ileum and the ileocecal orifice are not readily accessible from the ventral midline. When the aboral (distal) ileum is viable, the ileum can be transected 20 cm or more away from the ileocecal orifice and the stump of the ileum closed and left in situ. A blind stump of ileum should not be left in situ when it is necrotic. This will often lead to abscesses, local peritonitis, and fatal generalized peritonitis.[2] There are two methods for management of a necrotic ileal stump. The stump can be manually inverted into the cecum followed by blind oversew of the ileocecal orifice.[2, 3] Alternatively, the entire ileum can be resected with a stapling instrument placed at the ileocecal junction.

Veterinary surgeons regularly use three methods of jejunocecal anastomosis:[1, 2, 4–6] sutured end-to-side anastomosis, sutured side-to-side anastomosis, and stapled side-to-side anastomosis. A comparison between the sutured end-to-side and stapled side-to-side techniques revealed the stapled technique to be superior.[7] Horses with the end-to-side anastomosis had more mucosal edema and inflammation, with narrowing of the stoma 4 days after surgery, and they had significantly smaller stoma sizes at 30 days than those with stapled anastomoses. Horses with end-to-side anastomoses also showed colic within the first 24 hours after surgery. The sutured side-to-side anastomosis has not been compared with the other two methods. However, the sutured side-to-side method may be preferable to the end-to-side method because a larger stoma can be made between the jejunum and cecum. A disadvantage of the side-to-side anastomosis is that the open end of the transected jejunum must be closed before the anastomosis. This extra step requires additional surgical time. Our preference for jejunocecal anastomosis is the stapled side-to-side method. This procedure is rapid and clean, and it results in an adequate stoma when stapling techniques are performed properly. However, stapling equipment is expensive.[5] When stapling equipment is not available or surgeons are unfamiliar with the use of the equipment, we recommend the sutured side-to-side jejunocecal anastomosis.

Surgery

The principles of intestinal resection and anastomosis that were discussed in the preceding chapter on jejunal resection and anastomosis apply to ileal resection and jejunocecal anastomosis.

Sutured Side-to-Side Jejunocecal Anastomosis

The cause of the strangulation-obstruction should be identified and corrected. Bowel is evaluated for viability, and the section to be resected is isolated from the rest of the surgical field with towels and drapes. The cecum is maximally exteriorized and the apex retroverted. The ileum is exteriorized maximally and placed alongside the retroverted cecum. The mesentery of the ileum and jejunum is checked to ensure that it is not twisted or folded. The surgeon should be able to pass a hand unimpeded from the dorsal cecal band along the ileocecal fold to the ileocecal orifice and orally along the ileum to the jejunum (Fig. 19–1*A*). If not, the jejunum and ileum are rechecked to determine what abnormality is present, and the problem is corrected. Resection of ileum, when the most aboral aspect is healthy, can be done approximately 20 cm from the ileocecal valve, where exteriorization is possible.

A noncrushing occlusal clamp or Penrose[a] latex rubber tubing is placed as close to the ileocecal valve as possible, and one crushing resection clamp is placed at the level of the transection of the aboral aspect of the diseased segment of ileum (Fig. 19–1*B*). Occlusal and resection clamps are placed on the jejunum at the oral end of the section to be removed, as described for jejunal resection. The ileal artery and all jejunal arteries to be transected are triple ligated with size 2–0 polydioxanone[b] suture material. For ligation, arteries are isolated by blunt dissection with a hemostat. The ileum is transected aboral to the crushing clamp (see Fig. 19–1*B*). This prevents leakage of ingesta from the oral segment into the surgical field. Resection of the devitalized bowel is completed by transecting the mesentery, leaving two ligatures in the horse on each vessel, and transecting the oral end of the bowel to be resected. When decompression of distended jejunum oral to the diseased segment is desired, the ileum is transected at the aboral aspect of the diseased segment and placed over the side of the horse to serve as a conduit for fluids and ingesta out of the surgical field. After decompression, clamps are placed on the oral end, which is transected to complete resection of the diseased bowel. Temporary stay sutures are placed on the mesenteric and antimesenteric borders of the ileal stump for stability. The ileal stump is closed by a double-layer inverting pattern using size 2–0 polydioxanone. We prefer to use the Lembert pattern (see Fig. 19–1*B*) when the bowel is swollen and edematous. Alternatively, the ileal stump can be closed with a Parker-Kerr oversew (see Fig. 19–1*B*). This procedure requires two resection clamps on the ileum with transection of the ileum between the clamps. The Parker-Kerr clamp should have linear grooves on the jaws so that one can slide it off the ileum as the pattern is tightened. The Parker-Kerr oversew is easiest to use when the ileum is not swollen, edematous, or necrotic.

The closed stump of a necrotic ileum should be inverted into the cecum and fixed by oversewing the ileocecal orifice with size 0 polydioxanone suture material using a simple continuous pattern. Four to five bites are sufficient. Usually the knots must be tied blindly because the ileocecal orifice is difficult to visualize and impossible to exteriorize.

[a]Latex Penrose drain, Baxter Healthcare Corp., Round Lake, IL.

[b]PDS II, Ethicon, Inc., Somerville, NJ.

Figure 19–1.

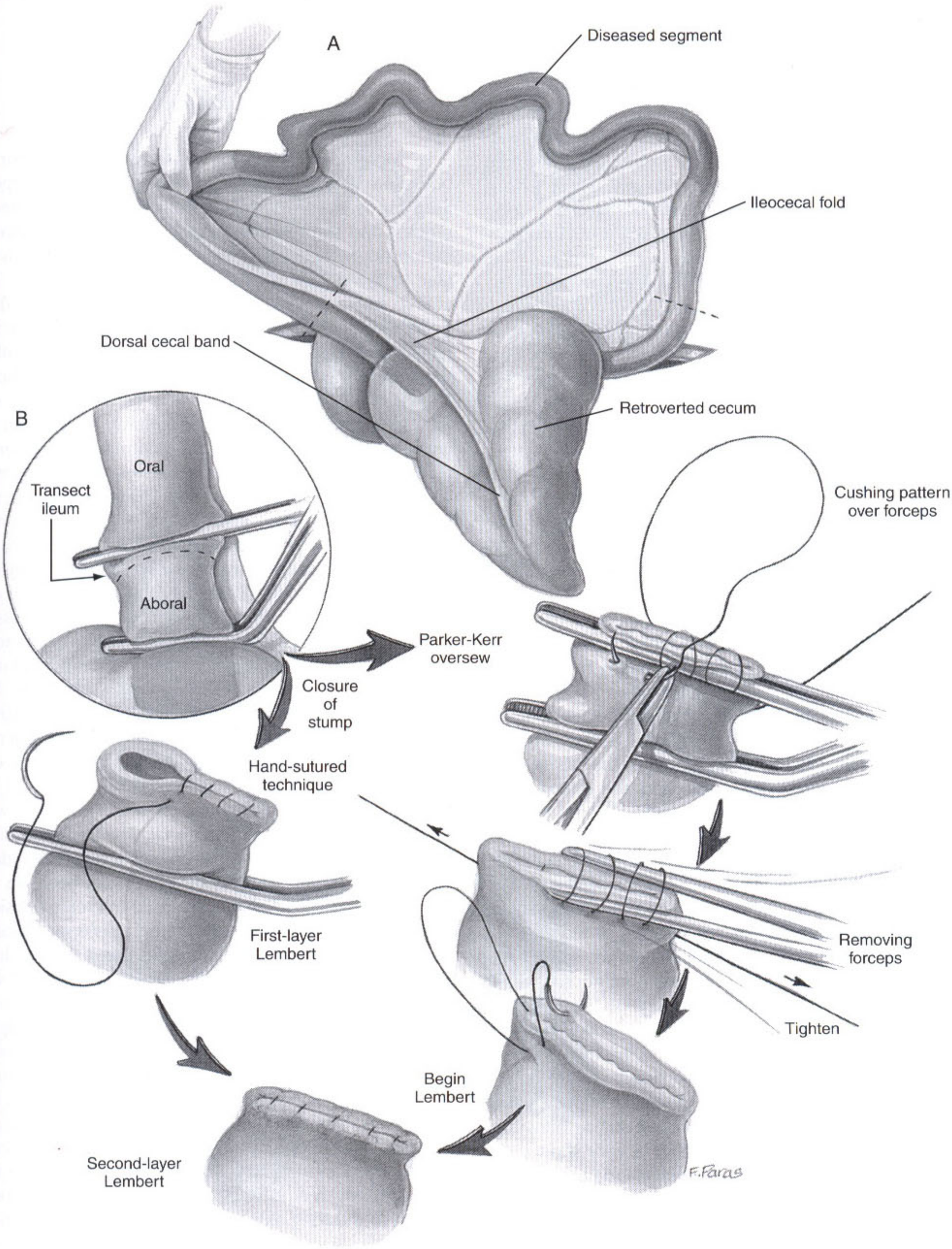


Illustration continued on page 107

Before anastomosis, the aboral end of the remaining viable jejunum is sutured closed with a Parker-Kerr oversew using size 2–0 polydioxanone suture material. The jejunum is anastomosed to the cecum between the dorsal and medial bands as close to the original ileocecal orifice as possible. The cecum is maximally retroverted so the apex points caudally and the jejunum is positioned next to the cecum with the stump facing toward the base of the cecum. The mesentery is rechecked to ensure that there is no volvulus and that the jejunum is not rotated along its axis. These errors will cause permanent twisting with postoperative obstruction. Two noncrushing angled 9-inch Glassman intestinal clamps[c] are placed across a sacculation of the cecum from which the ingesta has been removed by digital manipulation (Fig. 19–1*C*). A third occlusal clamp should already have been placed across the jejunum oral to the anastomotic site during transection. The antimesenteric side of the jejunum is opposed to the cecum with two stay sutures placed 12 cm apart.

The anastomosis should be performed close to the end of the jejunum to avoid a blind stump. We use size 2–0 polydioxanone suture material for all layers. The serosubmucosal layers of the jejunum and cecum are joined with a continuous Lembert pattern that is 8 to 10 cm long (see Fig. 19–1*C*). Suture bites are 3 to 4 mm apart. A linear incision immediately adjacent to the serosubmucosal suture line and slightly shorter is made into the lumen of the cecum and jejunum (Fig. 19–1*D*). Next, a continuous horizontal mattress is used to appose the mucosa on the far side (nearest the serosubmucosal suture line) of the stoma (Fig. 19–1*E*). The near-side mucosa is closed with a continuous Connell suture pattern to complete the stoma. Because the surgeon sutures the near side from the outside of the stoma, this pattern also inverts the mucosa into the stoma (Fig. 19–1*F*). Suture bites for closure of the mucosa should be 3 to 4 mm apart and approximately 5 mm from the cut edges of the mucosa. Finally, a separate Lembert pattern in the serosubmucosa is continued around the end of the stoma and back to its origin on the opposite end of the incision to complete suturing of the anastomosis (Fig. 19–1*G*). The mesenteric defect should be closed whenever possible.[2] A simple continuous suture line is used to oppose the mesentery of the jejunum over the stomal end of the jejunum to the dorsal band of the cecum, to the ileocecal fold, along the antimesenteric side of the ileum, over the stump of the ileum, and finally back to itself until the entire defect is closed (Fig. 19–1*H*). Large, loosely tensioned suture bites are sufficient. Transected mesentery that is very short cannot be sutured. Remaining large defects may not cause problems.[2]

The sutured side-to-side technique described for jejunocecal anastomosis can be used to unite nearly all bowel segments that can be apposed side to side. The sutured side-to-side technique has been used for ileocecostomy, gastrojejunostomy, cecocolostomy, colocolostomy, and jejunojejunostomy.

[c]Glassman noncrushing intestinal clamp, Allegiance Healthcare Corp., V. Mueller, Deerfield, IL.

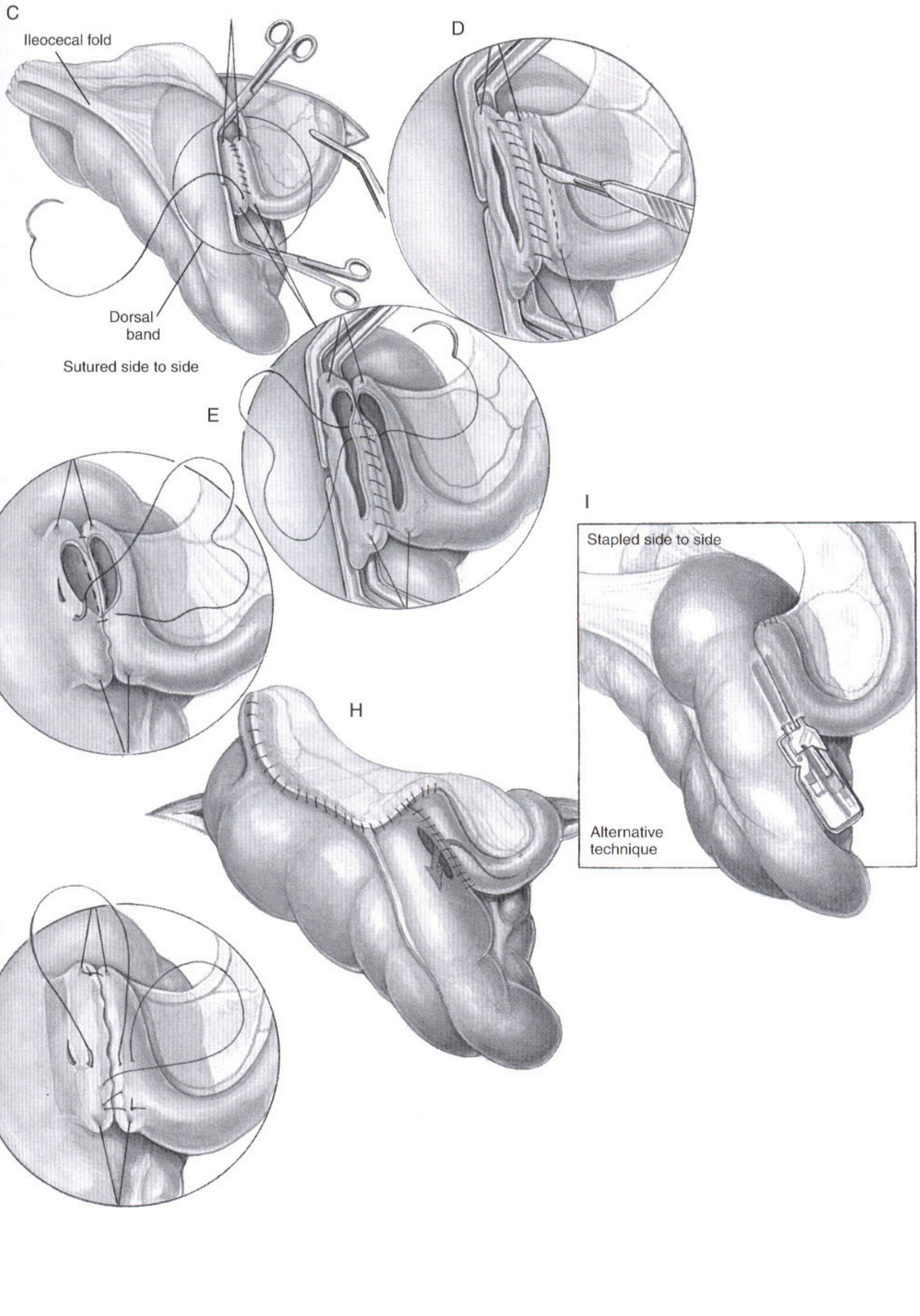
Stapled Side-to-Side Anastomosis

Mechanical stapling instruments for suturing bowel are widely used in human and veterinary surgery. Stapling is generally faster than hand-suturing techniques, and staplers can reduce or minimize contamination during surgical procedures. The major disadvantage to the use of stapling equipment is the cost. The LDS-2 stapler[d] (ligate-divide stapler) can be used to ligate and divide vessels in the mesentery very quickly. However, reinforcement of the stapled closure with a ligature on the side of mesentery to be left in the horse is recommended because the staples occasionally slip off the pedicle. The TA-90 Premium[e] stapler can be used to close the stumps of the ileum and the jejunum at the level of transection. This instrument forms a double staple line 90 mm long. The 4.8-mm-long staples should be used. Use of the TA-90 Premium is particularly advantageous when the entire ileum is necrotic. The entire ileum can be resected by placing the TA-90 instrument across the ileum at the ileocecal orifice. Visualization is often not possible. The ileal vessels should be ligated. Before transection of the ileum adjacent to the TA-90 instrument, a clamp should be placed on the ileum to prevent spillage into the abdomen. We prefer to use a 9-inch angled Glassman intestinal clamp. The necrotic ileum is often thick and edematous, and the staples from the TA-90 may become displaced. To avoid catastrophe, the stapled stump of the ileum is tucked into the cecum and oversewn with 1–0 polydioxanone suture material. The gastrointestinal anastomosis (GIA) stapler instruments produce two double rows of staples and divide the tissues between the double rows. These staplers are used to create the side-to-side stoma. The GIA 50 Premium[f] stapler produces a 52-mm-long line of staples. Staples are 3.85 mm long and when closed are about 1.5 mm long. The GIA 80-4.8[g] stapler produces a row of staples 85 mm long. These staples are 4.8 mm long and form closed staples about 2 mm long. The GIA 80-4.8 stapler is preferred, particularly when tissues are thickened and edematous.

To perform a stapled jejunocecal anastomosis, the jejunum is positioned next to the cecum and stabilized with two stay sutures placed 10 cm apart. The cecum should be occluded with clamps as described for the hand-suturing methods. A 1-cm stab incision perpendicular to the long axis of the bowel is made into both

[d]LDS-2, U.S. Surgical Corp., Norwalk, CT.
[e]TA-90 Premium, U.S. Surgical Corp., Norwalk, CT.
[f]GIA 50 Premium, U.S. Surgical Corp., Norwalk, CT.
[g]GIA 80-4.8, U.S. Surgical Corp., Norwalk, CT.

Figure 19–1. *Continued*



the jejunum and cecum approximately 8 cm from the end of the jejunum (Fig. 19–1*I*). One arm of the GIA 80-4.8 stapler is inserted into the lumen of each segment of bowel facing the blind end of the jejunum. The instrument is closed and actuated to simultaneously place two double staple rows and cut the tissues between them to create the stoma.

Alternatively, two GIA 50 Premium applications can be used to create the stoma. The stab incisions to admit the arms of the GIA 50 Premium are placed in the middle of the intended stoma. Double application of the GIA 50 ensures adequate stoma size. Double application of the staples is performed with the arms of the instrument facing in opposite directions from the stab incisions. The surgeon must be certain that the staple lines overlap at the point of divergence, or leakage of the anastomosis is likely.

After application of the GIA stapler, the common opening into the jejunum and cecum at the stab incisions should be closed perpendicular to the line of the staples forming the stoma. Closure is done with size 2–0 polydioxanone in a simple continuous pattern oversewn with a continuous Lembert pattern. The line of staples is supported at each end with a suture placed in the serosubmucosal layers of the cecum and jejunum. In effect, this keeps the staple line from being unzipped by tension on one end. The mesenteric defect is closed as previously described for sutured side-to-side anastomosis.

Comments

Complications after jejunocecal anastomosis are common and include leakage, peritonitis, adhesions, and postoperative ileus. However, the latter complication depends, to a large extent, on the systemic health of the horse, the condition of the remaining small intestine, and the amount of bowel that was resected.

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chapter 20

Large Colon Resection

Resection of the large colon at the level of the cecocolic fold has become a common surgical procedure in many equine practices.[1, 2] Lesions of the large colon that require resection include focal infarction, mural abscess, intussusception, and stricture. However, the most common cause for colon resection is damage caused by large colon volvulus. Large colon volvulus constitutes about 30% of the surgical colics in practices with large numbers of broodmares.[3, 4] Large colon resection is used to remove devitalized colon. Complete resection of lesions distal to the cecocolic fold is possible. However, when the volvulus of the large colon occurs at the junction of the transverse and right dorsal colons, all damaged colon cannot be removed. In some horses, the resection is performed in compromised bowel.[1] These horses have a poor prognosis for survival, but resection is performed when correction of the volvulus alone is deemed unlikely to be successful. In these horses, the colon is resected at the cecocolic fold to debulk the amount of ischemic or damaged colon and to reduce both the production and absorption of endotoxins and the translocation of bacteria. The colon in some horses will heal sufficiently for the wall to regain integrity against endotoxin absorption and bacterial translocation. These horses may survive. Horses with a colon that becomes nonviable after surgery will die. Prediction of which horses require colon resection is often difficult. Extensive large colon resection can be performed in horses to prevent recurrence of large colon volvulus. Recurrence in broodmares is common. In one study, 17% of all horses with volvulus had one recurrence, and 13% had two.[3] Colon resection is an alternative to colopexy.

Numerous methods for anastomosis of the colon after resection have been described. We usually perform colon anastomosis using an open end-to-end technique modified by creating a stoma between the dorsal and ventral colons within the common mesocolon.[1, 2, 5]

Anesthesia, Positioning, and Surgical Preparation

Horses requiring large colon resection will have significant metabolic abnormalities caused by the abdominal crisis that need to be managed before and during surgery. Fluid replacement, broad-spectrum antibiotics, and flunixin meglumine[a] should be given before surgery. Surgery is performed via a ventral midline celiotomy described in Chapter 16. This approach requires general anesthesia and positioning in dorsal recumbency. Suction is required. A large equine intestinal clamp[b] will facilitate resection of the colon but is not essential.

[a]Banamine, Schering-Plough Animal Health Corp., Kenilworth, NJ.

[b]Equine intestinal clamp Scudder style, 22 inch, Sontec Instruments, Englewood, CO.

Surgery

After ventral midline celiotomy, the large colon is exteriorized, and the volvulus is untwisted or other displacements are corrected. Most frequently, the colon volvulus is in a counterclockwise direction as the surgeon looks down on the ventral abdomen after celiotomy, and the colon must be untwisted in a clockwise direction. The colon is laid out on a colon tray[c] to the left side of the horse, and a pelvic flexure enterotomy is performed (Fig. 20–1*A*). The contents of the colon should be evacuated as completely as possible by flushing large amounts of water into it with a hose, and massaging the water and ingesta out of the enterotomy incision. Particular effort is made to remove fluid and ingesta from the right dorsal colon by sweeping a hand and arm under the colon and lifting up and outward. The pelvic flexure enterotomy does not need to be sutured.

The level of resection is determined; it should be close to the cecocolic fold when extensive resection is desired. However, transection should leave enough remaining colon so the cut ends are slightly above the level of the abdomen to facilitate isolation of the colons with wet towels and drapes and to facilitate suturing. The colonic vessels are isolated from the mesocolon and double ligated using transfixion ligatures at the level of resection. Venous branches tend to ooze, requiring careful hemostasis. Stay sutures are placed on the ventral and dorsal colons just proximal to the level of resection. When a large equine intestinal clamp is available, it can be placed transversely across the colons and used as a guide for transection with a scalpel. The colons are transected so the clamp stays with the discarded colon. The colon is amputated freehand when no clamp is available. Amputation opens the lumina of the right ventral and dorsal colons. An assistant should pull up on all stay sutures so the open ends of the colon are facing directly up. This will stabilize the colons and reduce contamination from residual fluid and ingesta within the bowel (Fig. 20–1*B*). Vessels along the cut edge that bleed significantly should be ligated. Suction is used as needed to remove blood and intestinal fluids.

Scissors are used to cut longitudinally between the colons within the common mesocolon for a distance of 10 to 12 cm. The cut edges of mucosa of the right dorsal colon are opposed to the mucosa of the right ventral colon with a simple continuous suture pattern using size 0 polydioxanone[d] suture material (Fig. 20–1*C*). When the colon is swollen and edematous, this pattern can be repeated to create a double row of sutures.[2] Only the cut edges of mucosa from the longitudinal incision within the mesocolon are closed with this pattern. An alternative technique for creating this part of the anastomosis within the mesocolon is to use stapling equipment.[5] A GIA 80-4.8[e] instrument can be inserted longitudinally with one arm of the stapler in each colon. The stapler is discharged once, creating an 85-mm-long stoma between the colons. Oversew of the stapled stoma is not necessary. Hand suturing should be done when the colon is extremely swollen and edematous, thus making staple failure possible.

The open ends of the colons are brought together and positioned end to end so that the antimesenteric sides of both colons are in apposition. The colons are closed with two full-thickness suture patterns using size 0 polydioxanone suture material. The first layer is a simple continuous pattern (Fig. 20–1*D*). Closure starts next to the longitudinal stoma within the mesocolon, and the suture lines go in opposite directions around the circumference of the colons to the antimesenteric sides. This creates an end-to-end anastomosis. There is space for two surgeons to work simultaneously. Suture bites should be taken approximately 8 mm from the cut edges of the bowel and should be 8 mm apart. The entire circumference of the end-to-end anastomosis is oversewn with a continuous Lembert pattern using size 0 polydioxanone suture material (Fig. 20–1*E*). The stay sutures are removed, the bowel is cleaned with moist sponges, and the soiled drapes are removed. Extensive lavage is avoided because the resection is conducted at or within the laparotomy incision. This same end-to-end open technique can be used for less extensive resection of the colons, such as removal of the left colons at the sternal and diaphragmatic flexures. Resection and anastomosis of the colons distal to the cecocolic ligament is easier because exteriorization is better and abdominal contamination less likely.

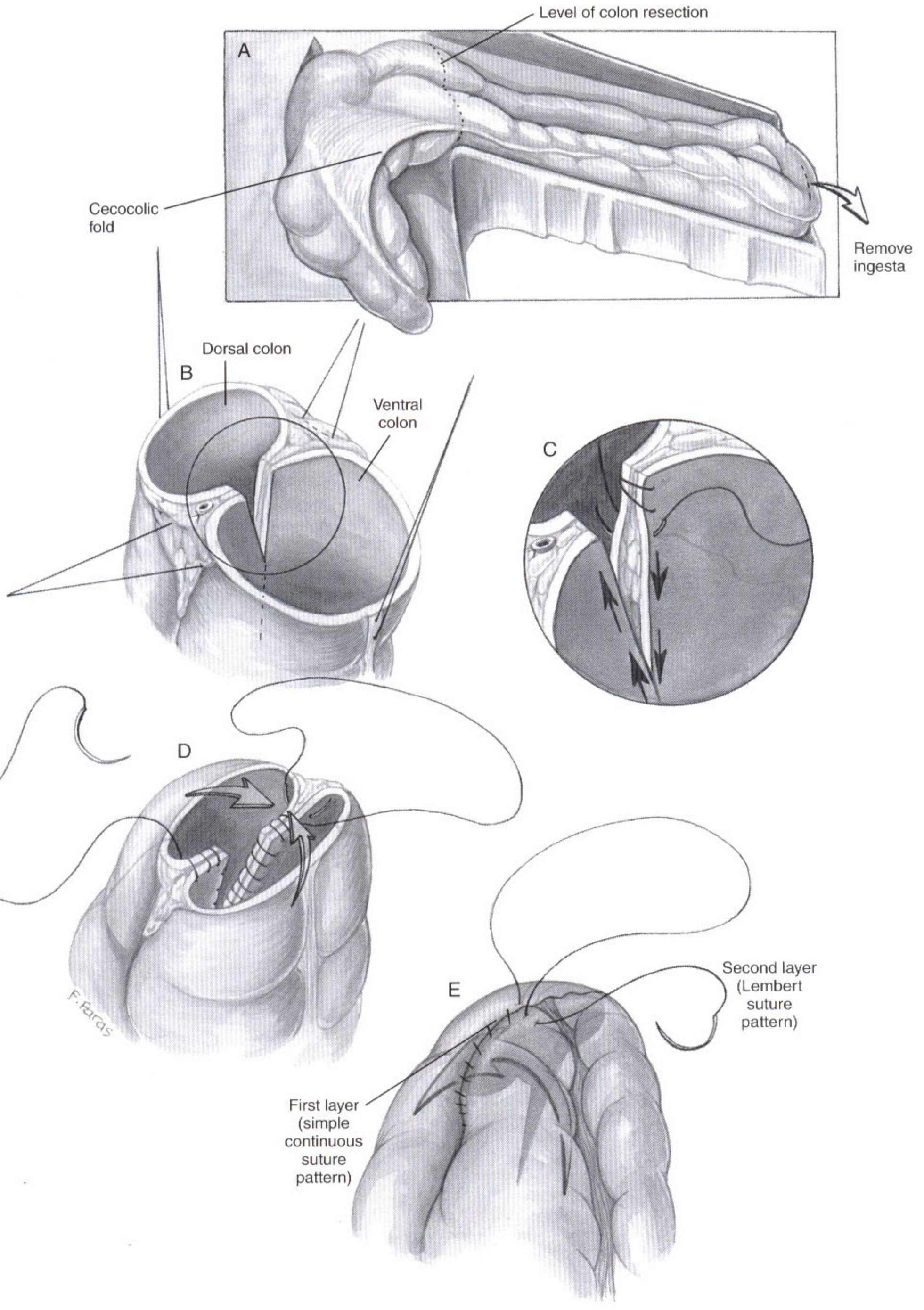
Postoperative Care

Horses requiring extensive resection are typically extremely ill from shock and sepsis and require intensive care. Treatment includes the administration of intravenous fluids, plasma, antibiotics, and nonsteroidal anti-inflammatory drugs.[1] Prevention of laminitis with hoof support and systemic medications such as heparin should be considered. In addition to shock and laminitis, horses may experience peritonitis, abdominal pain, hemorrhage from the colons, and colon necrosis, leading to death.

Resection of the large colon at the cecocolic ligament in normal horses causes a decrease in digestion of dietary crude fiber, cellulose, and phosphorus.[6] Fecal water output and total fecal output are increased, and horses lose weight after surgery.[6] Grass hay does not provide adequate energy. The long-term diet after ex-

[c]Colon tray, Kimzey, Inc., Woodland, CA.
[d]PDS II, Ethicon, Inc., Somerville, NJ.
[e]GIA 80-4.8, U.S. Surgical Corp., Norwalk, CT.

Figure 20–1.


Level of colon resection
A
Cecocolic fold
Remove ingesta
Dorsal colon
B
Ventral colon
C
D
F. Paras
Second layer (Lembert suture pattern)
E
First layer (simple continuous suture pattern)

tensive colon resection should include high-quality feed and free access to water.

The prognosis depends on the preoperative health of the horse and the amount of colon resected. Horses undergoing resection of 60% length or less of the large colon undergo adoptive changes and need no special diet.[7] On the basis of several studies, the survival rate of horses after colon resection is between 50 and 60%.[1, 2, 6, 8]

End-to-end anastomosis of the large colons at or near to the cecocolic ligament without making a longitudinal mesocolic stoma is an acceptable modification of this technique.[8] For very short or focal lesions of the colon, a simple end-to-end anastomosis performed in a very similar manner to an end-to-end jejunal anastomosis is recommended. A two-layer closure using size 0 polydioxanone suture material is performed. A simple continuous full-thickness suture pattern around the circumference of the anastomosis is oversewn with a continuous Lembert pattern.

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chapter 21

Colopexy

Colopexy is performed to prevent recurrence of large colon volvulus or right dorsal displacement. Volvulus or displacement occurs more frequently in broodmares than in other horses. In practices located near large populations of broodmares, colon volvulus or displacement is the most common cause of colic requiring surgery.[1,2] Recurrence of large colon volvulus has been reported in 5 to 15% of horses.[1,2]

Colopexy is not a benign procedure. Complications include intermittent abdominal pain, breakdown and failure of the colopexy, cecal tympany, extensive abdominal adhesion formation, incisional infection, subcutaneous fistulous tracts, incisional hernia, and catastrophic rupture of the left ventral colon.[1,2] Fatal complications occur in approximately 7% of horses.[1] The risk of fatal complications must be weighed against the risk of recurrence and death from recurrence as well as the costs of additional surgery. In one study, the overall survival rate for horses with large colon volvulus and right dorsal displacement that did not have colopexy at surgery was 80.7%, and the survival rate in horses receiving colopexy was 86%.[1] Colopexy generally should be reserved for horses with recurrent disease.[1,3] However, some surgeons perform colopexy at the first surgery on 5- to 12-year-old broodmares that are at high risk for recurrence.[2] Clients should be educated regarding the risks versus the benefits of the procedure and should be involved in the decision for or against the procedure. Colopexy may be inadvisable on performance horses because of the risk of postoperative pain associated with tension on the colopexy during exercise, but it has been successful in some performance horses.[4] Colopexy should not be performed when the large colon is severely edematous and the integrity is compromised.[3] An alternative to colopexy for prevention of large colon volvulus or displacement is colon resection.[5] Colon resection is essential to survival of the horse if the colon is necrotic.

Surgery

Colon displacement or volvulus is corrected via a standard ventral midline celiotomy. Pelvic flexure enterotomy for removal of fluids, ingesta, and toxins is performed when the colon is full. Enterotomy may not be necessary on horses undergoing surgery within a short period of time after the onset of colic. These horses generally require needle decompression of gas, if anything. The colon is evaluated for viability and, when viable, is placed in a normal anatomic position within the abdominal cavity.

The technique for colopexy is a modification of the procedure described by Hance and Embertson.[1] Two towel clamps are placed through the left side of the linea alba and are used by an assistant to elevate the left abdominal body wall. A 20-cm-long incision parallel to the ventral midline incision and 10 cm to the left lateral side is made in the peritoneum. The retroperitoneal fat is bluntly separated to expose the internal rectus fascia (Fig. 21–1*A*). A paramedian skin and subcutaneous incision 20 cm long, directly superficial to the peritoneal incision, is made to expose the external rectus fascia (Fig. 21–1*B*). The lateral band of the left ventral colon is sutured to the internal rectus fascia using size 2 polypropylene[a] suture material in an interrupted cruciate suture pattern. The cruciate stitch is started from outside the abdomen. The suture passes through both rectus fascia layers into the abdomen, is placed through the lateral tenia without penetrating the lumen of the bowel, and passes back through the fascia to the subcutaneous space (Fig. 21–1*C*). This same sequence is repeated approximately 1 cm away from the first pass to form a cruciate pattern, and the suture ends are tied. Eight to 10 cruciate stitches are used to appose the lateral band of the left ventral colon to the internal rectus fascia (Fig. 21–1*D*). The subcutaneous tissues over the colopexy site are closed with size 2–0 polydioxanone[b] suture material, and skin is closed routinely. The ventral midline celiotomy also is closed routinely. Another method to expose the external rectus fascia is to dissect laterally from the ventral midline incision in the subcutaneous tissues. The skin is elevated from the colopexy site. This method creates dead space in the subcutaneous tissues, which should be closed before closure of the ventral midline celiotomy.

Hunt and Spirito reported on an alternative method for colopexy in which 10 to 15 cm of the lateral free band of the left ventral colon is incorporated into the closure of a cranial ventral midline incision.[2] The ventral midline laparotomy is performed just caudal to the sternum.[2] The surgeon must anticipate performing a colopexy before opening the abdomen for colic surgery in order to make a cranial ventral midline incision. The advantages of this technique are that minimal additional surgical time is required for the colopexy, the colon volvulus is easy to correct from the cranial incision, and the cranial position of the colopexy does not interfere with uterine expansion.[2]

[a]Prolene, Ethicon, Inc., Somerville, NJ.
[b]PDS II, Ethicon, Inc., Somerville, NJ.

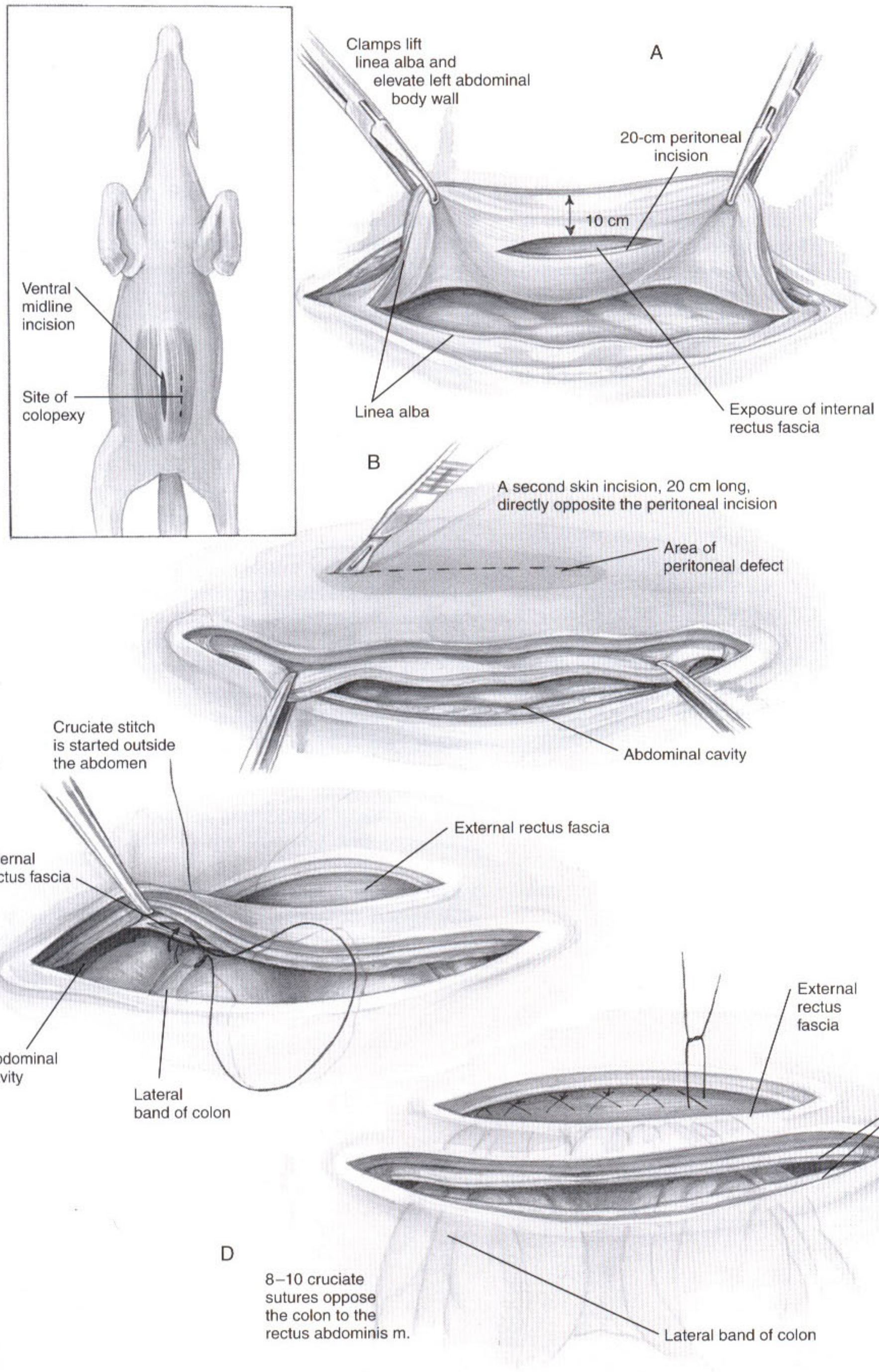
Postoperative Care

Treatment of horses postoperatively is aimed at managing shock and pain and preventing sepsis. Fluids, electrolytes, nonsteroidal anti-inflammatory drugs, and antibiotics are routinely administered to these horses. Intermittent mild colic from the colopexy often occurs for 2 to 3 weeks after surgery and occasionally longer.

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Figure 21–1.


Ventral midline incision
Site of colopexy
A
Clamps lift linea alba and elevate left abdominal body wall
20-cm peritoneal incision
10 cm
Linea alba
Exposure of internal rectus fascia
B
A second skin incision, 20 cm long, directly opposite the peritoneal incision
Area of peritoneal defect
Abdominal cavity
C
Cruciate stitch is started outside the abdomen
External rectus fascia
Internal rectus fascia
Abdominal cavity
Lateral band of colon
External rectus fascia
Linea
D
8–10 cruciate sutures oppose the colon to the rectus abdominis m.
Lateral band of colon

chapter 22

Flank Laparotomy

The transverse flank approach to the abdominal cavity may be used for minor exploratory surgery, biopsy procedures, correction of uterine torsion, colostomy, and ovariectomy.[1–3] This approach is not recommended for horses with acute abdominal crises. The approach can be made on either the right or the left side of the abdomen, depending on what structures are to be examined, biopsied, or removed. Flank laparotomy for correction of uterine torsion should be made on the side of the abdomen toward which the uterus twists.[1] Flank incisions can be performed on standing or anesthetized horses. The advantages of a standing flank laparotomy are that (1) general anesthesia is avoided, (2) organs are positioned in situ, (3) minimal surgical assistance is needed, (4) no specialized equipment is required, and (5) closure of the incision is secure and easy to perform. However, the standing transverse flank laparotomy is performed infrequently because current methods of general anesthesia are safe, exposure of viscera is limited, and laparoscopy provides better visualization. In recent years, the security and integrity of ventral midline incision closure have improved with the development and use of strong, absorbable suture materials. These developments have decreased the necessity for standing flank laparotomy. The technique for making and closing transverse flank incisions is identical in the standing and recumbent horse.

Transverse flank laparotomy in the recumbent horse is indicated for loop colostomy in horses with rectal tears and for unilateral ovariectomy. This approach is particularly useful for removal of ovarian granulosa cell tumors up to 15 cm in diameter that have short ovarian pedicles. The short pedicle makes exteriorization of the ovary and ligation of the pedicle difficult through a ventral abdominal incision.

Anesthesia, Positioning, and Surgical Preparation

Hair should be removed and the skin surgically prepared from an area delineated by the fold of the flank, the 14th rib, the greater trochanter, and a line 10 cm from dorsal midline on the opposite side of the abdomen from the incision site. The horse is sedated, and a line block using up to 100 ml of mepivacaine hydrochloride[a] is performed when the transverse flank laparotomy is to be done on the standing horse. The local anesthetic is injected directly along the incision line subcutaneously and into all layers of the body wall. This procedure often requires a 2½- or 3-inch-long needle because the muscles of the body wall are thick. Horses undergoing surgery while anesthetized are positioned in lateral recumbency with the upper hindlimb pulled back 10 to 15° to open the abdominal space between the ribs and the thigh muscles. Regardless of the position, full draping and aseptic technique are used for the surgery.

[a]Carbocaine-V, Sterling Drug, Inc., McPherson, KS.

Surgery

The transverse flank laparotomy is performed using a modified grid technique to separate the abdominal muscles.[1] A nearly vertical incision through the skin, subcutaneous tissue, and cutaneous trunci muscle is made starting at a point midway between the last rib and the ventral part of the tuber coxae and extending 20 cm ventrally and slightly caudally (Fig. 22–1*A*). The external abdominal oblique muscle and its aponeurosis are incised in the same direction as the skin incision (Fig. 22–1*B*). The internal abdominal oblique muscle is very thick and fleshy and is covered by a thin, glistening aponeurosis. The muscle is bluntly separated along the direction of its fibers starting at a point in the center of the incision (Fig. 22–1*C*). This point should be below the tuber coxae to gain length in the separation of the muscle fibers. The transverse abdominal muscle is cut along its fibers in a direction parallel to the skin incision, exposing retroperitoneal fat and peritoneum. The fat is bluntly separated, and the peritoneum is grasped with a thumb forceps, tented toward the surgeon, and opened with blunt-blunt scissors. The incision in the peritoneum is extended along the same plane as the separation of fibers in the transverse abdominal muscle. When the surgeon anticipates passing a hand and arm through the flank incision multiple times, we recommend placement of a 7- or 9-inch wound-protector ring drape[b] to protect the muscles, which become edematous during the manipulation and are easily damaged. The modified grid technique provides limited visualization of the abdominal cavity but enough exposure for easy insertion of a hand and arm, for palpation of the abdominal cavity, and for exteriorization of viscera.

The transverse flank laparotomy is closed with three layers of simple continuous sutures. Suture bites in the muscle layers can be placed approximately 1 cm apart and 1 cm from the edges of the wound. The transverse abdominal muscle is usually not sutured. The fleshy internal abdominal oblique closes under its own tension and usually does not need to be sutured. Several interrupted sutures can be used to approximate this fleshy muscle if it has been stretched. Size 1 polydioxanone[c] suture material is used to close the external abdominal oblique muscle. The suture bites need to be placed only in the superficial fascia of this muscle. During closure, the sutures should not be pulled too tightly, or the risk of tearing muscle tissue or causing muscle necrosis increases. The subcutaneous trunci muscle and associated areolar fascia are closed with size 1–0 polydioxanone material. The skin may be closed with any suitable noncapillary, nonabsorbable suture material. We do not routinely place a drain in the wound. Closure of the transverse flank laparotomy is secure because the muscles tend to close themselves with the grid technique, and the full weight of the abdominal viscera does not press on the incision.

Postoperative Management

Horses should be rested for 4 weeks for healing of the incision, at which time light exercise can resume. Skin sutures are removed in 7 to 10 days. Seroma formation is common when manipulation through the grid incision has been extensive. Other complications, including wound infection and dehiscence, are rare. Unlike ventral incisions, dehiscence is not generally associated with eventration of viscera.

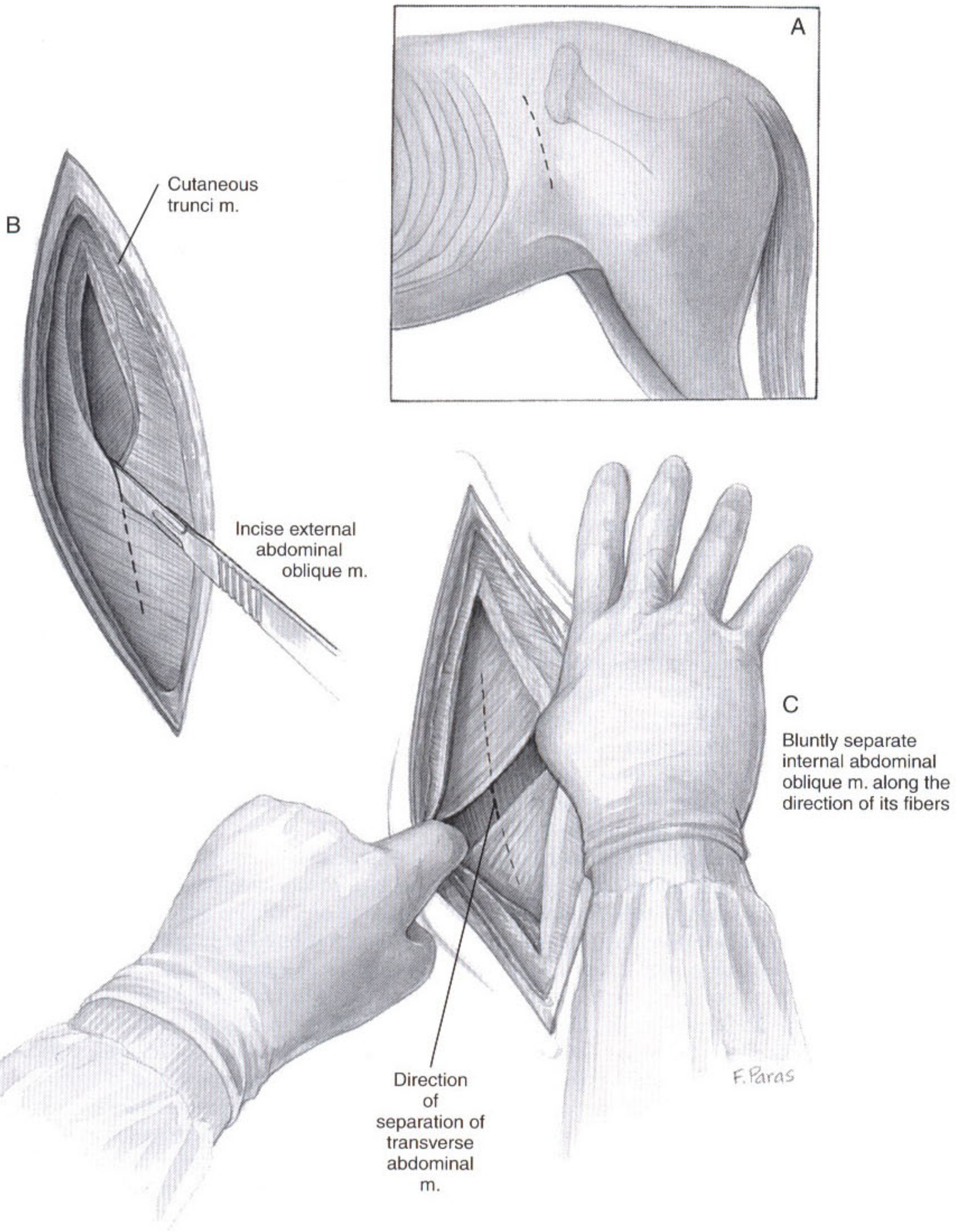
[b]Vi-Drape wound protector, Becton Dickinson AcuteCare Division, Franklin Lakes, NJ.

[c]PDS II, Ethicon, Inc., Somerville, NJ.

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Figure 22–1.


A
B
Cutaneous trunci m.
Incise external abdominal oblique m.
C
Bluntly separate internal abdominal oblique m. along the direction of its fibers
Direction of separation of transverse abdominal m.
F. Paras

chapter 23

Management of Rectal Tears

Rectal tears are caused most often by rectal palpation, although they also can be caused by enemas, dystocia, meconium extraction with forceps in foals, and misdirection of a stallion's penis during mating.[1] Grade 1 tears involve the mucosa or submucosa or both. Grade 2 tears are uncommon and involve separation of the muscularis only. Prognosis for Grade 1 and 2 tears is generally good. Grade 3 rectal tears involve disruption of all layers of the rectum except the serosa or mesorectum, and Grade 4 tears are complete. Grade 4 tears allow direct communication between the rectum and the peritoneal cavity. The more severe Grade 3 and Grade 4 tears are serious and often fatal. Severe tears require immediate first aid and timely surgical intervention for survival of the horse. Grade 3 tears often impact with feces and convert to Grade 4 tears. Rectal packing immediately after injury will prevent conversion of Grade 3 tears to Grade 4 tears.[2] Appropriate treatment of Grade 3 tears results in a greater than 50% survival. Immediate treatment of Grade 4 tears is indicated, but horses with Grade 4 tears rarely survive because contamination of the peritoneal cavity with feces and bacteria results in fatal peritonitis.

Immediate first aid for rectal tears includes reduction of colon motility, epidural anesthesia to reduce straining, removal of feces from the rectum and from the tear, packing the rectum with a cotton-filled stockinette, administration of antibiotics and nonsteroidal anti-inflammatory drugs, intravenous fluid administration, and tetanus prophylaxis. Fresh tears should be closed with sutures when possible. Rectal tears have been sutured through the anus using a blind one-hand suture technique, through the anus using special long-handled instruments and a 60-cm-long expandable rectal speculum, after prolapse of caudal rectal tears through the anal sphincter, and via a ventral midline celiotomy.[1–4] Suture closure of rectal tears is difficult and not always possible because rectal tears are often located in the dorsal rectum 25 to 35 cm from the anus.[3] Diversion of feces away from rectal tears with either a colostomy or temporary indwelling rectal liner will protect both sutured and unsutured tears. Unsutured tears are protected from contamination with feces while healing occurs by second intention. Sutured tears may be protected from suture line dehiscence and from contamination if partial dehiscence occurs. Fecal diversion by colostomy or insertion of a temporary indwelling rectal liner will assist the healing of rectal tears and allow survival of some horses that otherwise would die.

Loop colostomy consists of pulling a loop of small colon proximal to the tear through a lower left flank incision, opening the antimesenteric side of the bowel, and fixing it to the body wall. The colon is not transected. Loop colostomy has been used successfully to treat horses with Grade 3 rectal tears.[5,6] Loop colostomy is most effective when performed shortly after the injury to the rectum. Loop colostomy provides complete diversion of feces from the caudal rectum, reducing disruptive forces on the tear from peristalsis and the passage of fecal balls. Loop colostomy may also be used to bypass the caudal small colon or rectum for management of horses with rectal strictures or pelvic abscesses. Reversal of the loop colostomy requires a second surgery performed under general anesthesia.

The main advantage to the temporary indwelling rectal liner is that it requires one surgical procedure. The liner generally is sloughed out of the rectum in 9 to 12 days, but it may slough out earlier. The temporary indwelling liner requires continuous postoperative maintenance to prevent fecal impaction at the plastic ring, which is sutured into the lumen of the small colon. The temporary indwelling rectal liner is not recommended for rectal tears that are greater than 25% of the circumference of the rectum and for tears in horses in which the small colon is of insufficient diameter to accommodate the 5-cm-diameter plastic ring of the rectal liner.[7] Temporary indwelling rectal liners have been used successfully to treat Grade 3 tears as well as Grade 4 tears when inserted before the peritoneal cavity has been contaminated.[7]

Loop Colostomy

Anesthesia, Positioning, and Surgical Preparation

Loop colostomy can be performed on the standing sedated horse using local anesthesia or with the horse anesthetized and positioned in right lateral recumbency. Standing surgery will reduce the risk of trauma to the colostomy stoma during recovery from general anesthesia but prevents removal of colon contents via a pelvic flexure enterotomy.[6] The hair is removed and the flank surgically prepared as described for transverse flank laparotomy, except hair removal and preparation extends to 6 inches below the fold of the flank. In addition to local anesthesia of the site for flank laparotomy, anesthesia is infiltrated along a 10-cm line in the subcutaneous tissues and muscles cranial and slightly above the fold of the flank. The line of anesthesia and the subsequent incision are parallel to the last rib. Routine draping and aseptic technique are used. General anesthesia may be selected when it is anticipated that the rectal tear is accessible for direct suturing via a ventral midline celiotomy. Direct suturing is done first with the horse in dorsal recumbency. The large colon should be emptied of ingesta through a pelvic flexure enterotomy to reduce passage of feces through the colostomy in the early postoperative period. The loop of colon at the colostomy site is sutured and tagged. The tags may be passed through the flank just adjacent to the colostomy site and may be used to locate the colon. After closure of the ventral midline incision, the horse is rolled to right lateral recumbency for the colostomy.

Surgery

The loop colostomy is performed the same way on horses standing or anesthetized. A double-incision loop colostomy on the standing horse is described.[5] The modified grid transverse flank laparotomy is performed to gain entrance to the abdomen. The small colon is identified, and a segment oral to the rectal tear, approximately in the middle of the small colon, is exteriorized through the flank incision. This segment is folded to form a loop with the small colon apposed on itself (Fig. 23–1*A*). The colon is joined with an 8-cm-long continuous Lembert pattern using size 0 polydioxanone[a] suture material. As the suture line approaches the end loop, it should be close to the mesocolon so that the antimesenteric band is outermost (see Fig. 23–1*A*). The sutured loop is placed back into the abdomen. A second 8-cm-long incision in the flank is made cranial to and just above the fold of the flank parallel to the last rib. The sutured loop of small colon is manipulated through the lower incision until it protrudes above the skin for 5 to 8 cm (Fig. 23–1*B*). The oral segment must be cranioventral in the incision. The second incision in the body wall may have to be extended to allow exteriorization of the loop. The body wall should form a snug, but not tight, fit around the loop of small colon after the loop is properly positioned. The seromuscular layer of the loop is sutured to the subcutaneous tissues with size 0 polydioxanone[a] suture material using simple interrupted sutures placed 6 to 8 mm apart (see Fig. 23–1*B*). An incision through the antimesenteric band into the lumen of the small colon is made along the outside curvature of the loop for 7 to 8 cm. The full-thickness cut edge of colon is sutured to the skin using size 0 polydioxanone or size 0 polypropylene[b] suture material in a continuous or interrupted pattern to form the stoma (Fig. 23–1*C*).

When general anesthesia is used for surgery, the loop is formed and tagged with sutures, which are passed through the body wall adjacent to the colostomy site using a long needle. The horse is rolled to right lateral recumbency, and the 8-cm incision above the flank fold is made. The loop is then identified and pulled through the incision. Care must be taken to achieve proper orientation of the loop.

Postoperative Management

Horses should be fed a laxative, low-bulk diet. Petroleum jelly or other suitable ointment should be applied to the skin around the stoma to reduce moisture dermatitis. The stoma and surrounding skin should be cleansed daily.[5] Rectal tears left to heal by second intention can be flushed gently via an endoscope every 1 to 3 days.[6] Provided the tear is healing satisfactorily, the entire colon aboral to the colostomy can be flushed daily with up to 20 L of warm water to clean out secretions and reduce atrophy of the aboral segment. Antibiotics, fluids, nonsteroidal anti-inflammatory drugs, peritoneal lavage, and other means of treatment for the peritoneal contamination and shock caused by the rectal tear should be pursued vigorously.

[a]PDS II, Ethicon, Inc., Somerville, NJ.
[b]Prolene, Ethicon, Inc., Somerville, NJ.

Figure 23–1.

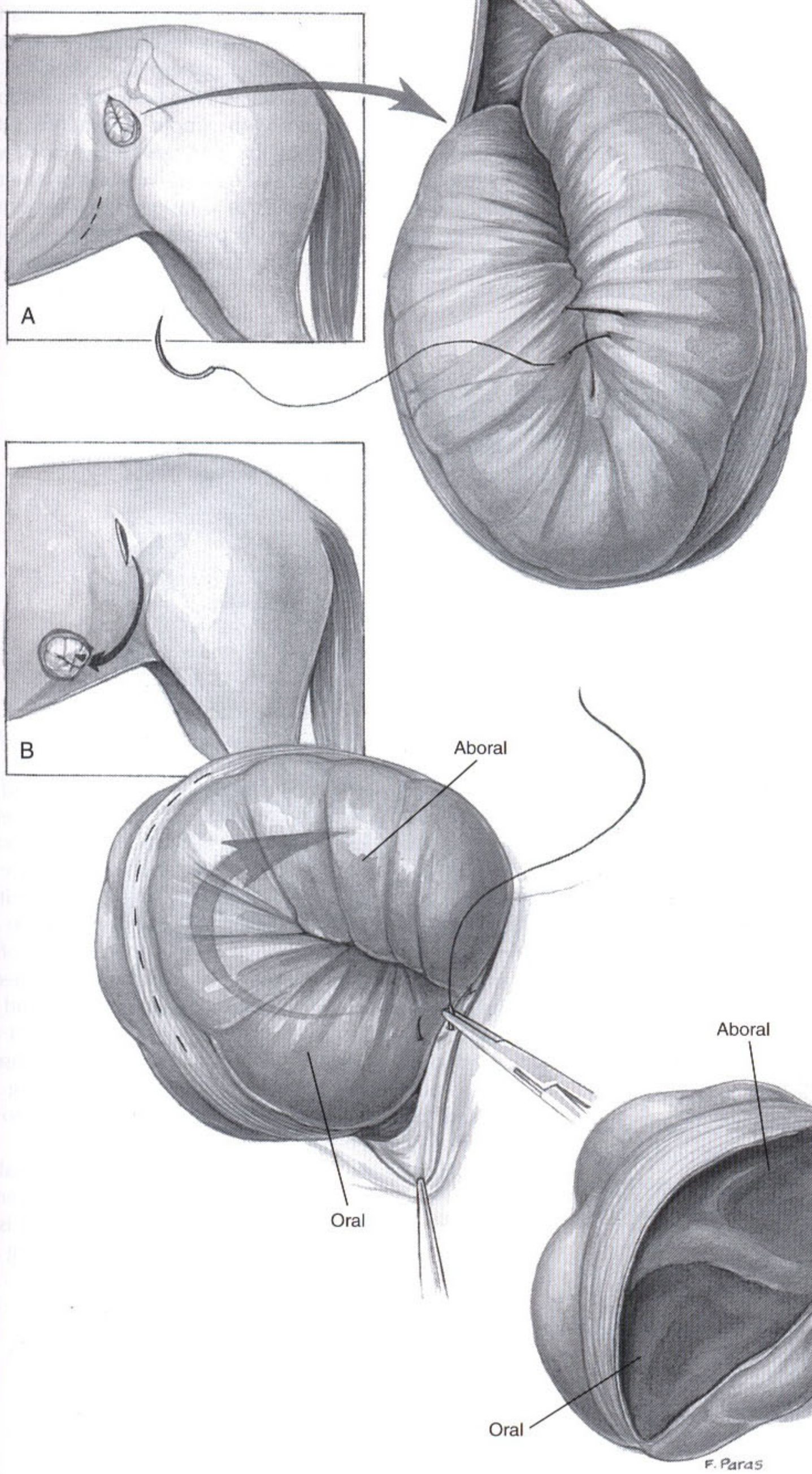


Illustration continued on page 127

Colostomy Reversal

Colostomies may be reversed after healing of the rectal tear. The horse is anesthetized and placed in right lateral recumbency. The hair around the colostomy stoma is removed, and the site is surgically prepared. A circumferential skin incision 1 cm from the edge is made around the colostomy stoma. The margin of the skin is sutured over the open stoma using a simple continuous pattern. A second surgical preparation is performed, and the colostomy and small colon are resected en bloc from the body wall and exteriorized. The small colon is transected on both sides of the stoma. The aboral end of the small colon should be transected at a 45° angle to provide a larger opening that more closely matches the size of the oral segment. End-to-end small colon anastomosis is performed with a two-layer technique. The colon is closed with a full-thickness simple interrupted suture pattern oversewn with a continuous Cushing pattern (see Chapter 18). The surgery site is lavaged and the flank incision closed in three or four layers with simple continuous suture patterns. Apposition of the muscles of the body wall should be done with size 1 polydioxanone suture material. Mattress sutures or a far-near-near-far pattern can be used if tension is present.[6] After reversal of the colostomy, feces should be kept soft and in low volume.

Insertion of a Temporary Indwelling Rectal Liner

Anesthesia, Positioning, and Surgical Preparation

The temporary indwelling rectal liner is constructed using a 10-cm-long, 5-cm-diameter rectal ring[c] and a 5 × 96-inch arthroscopy camera drape[d] (Fig. 23–2).[7] Rectal palpation sleeves may be used in place of the camera drape but may not be long enough in some horses. Rectal liners should be made ahead of time because rectal tears in horses are emergencies, and construction time can delay treatment. The 10-cm-long rectal ring is cut on each end to form a 7.5-cm-long ring. The cut edges should be filed until smooth. Holes are drilled 1 cm apart around the circumference of the ring along one edge of the central groove, and size 5 polyester[e] suture material is laced through the holes to form an anchor suture. The narrow end of the arthroscopy camera drape is cut off. The ring is inserted almost completely into the cut end of the camera drape, with the anchor suture side of the central groove inserted first. The drape is secured to the ring with a heavy rubber band, which goes around the drape and ring over the central groove on the opposite end of the anchor stitch. The cut edges of the drape are glued to the ring with cyanoacrylate[f] or silicon[g] glue, and the drape is inverted over the ring and rubber band and glued to itself (Fig. 23–1*D*). A long strand of nonabsorbable suture material may be attached to the ring and passed through the lumen of the camera drape to aid retrieval of the ring after insertion.

Horses are anesthetized, positioned in dorsal recumbency, and surgically prepared for a caudal ventral midline celiotomy. Any remaining fecal material is removed from the rectum and tear. Surgical draping and aseptic precautions are routine.

[c]Rectal ring, Regal Plastic Co., Detroit Lakes, MN.

[d]Arthroscopy camera drape, 5 inch × 96 inch, Linvatec Corp., Largo, FL.

[e]Ticron, Davis & Geck, Inc., American Cyanamid Co., Manati, PR.

[f]Superglue, Loctite Corp., Cleveland, OH.

[g]Shoe Goo adhesive, Electric Products, Inc., Carson, CA.

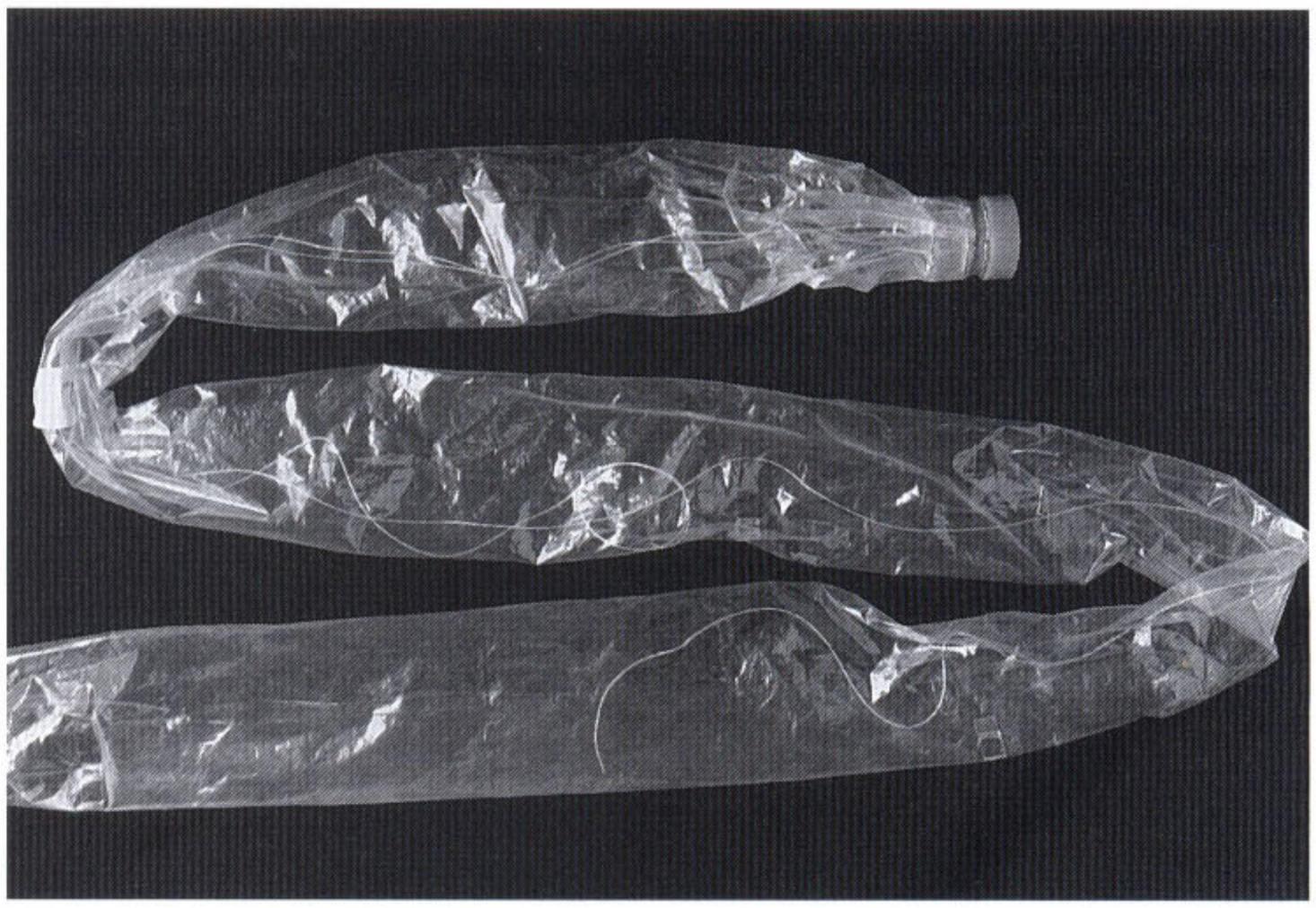


Figure 23–2.

A rectal sleeve made from a rectal prolapse ring and arthroscopy camera drape.

Surgery

The method of insertion of the rectal liner is adapted from the original description by Taylor, Watkins, and Schumacher.[7] A caudal ventral midline celiotomy 20 to 25 cm long is made (Chapter 16), and the small colon is identified and exteriorized. Extremely deep tears may be identified and sutured. An unscrubbed assistant carefully passes a well-lubricated rectal liner through the anus to a position oral to the rectal tear. With assistance from the surgeon, the assistant manipulates the ring of the rectal liner until it rests in an area where it can be palpated within a section of the small colon that can be exteriorized through the midline incision. The ring should be as far aboral as possible, and the end of the plastic drape must pass out of the anus. A circumferential ligature of size 1 polyglycolic acid[h] suture material is placed around the intestine over the central groove of the rectal ring and tied tightly to constrict the serosal surface (Fig. 23–1*E*). Four to six simple interrupted sutures using size 1 polyglycolic acid suture material are equally spaced around the circumference of the small colon. The sutures pass through the small colon adjacent to the circumferential ligature, underneath the anchor suture, and back up through the colon, and they are tied around the circumferential ligature to anchor the plastic ring to the small colon (see Fig. 23–1*E*). Interrupted Lembert sutures with size 1–0 polydioxanone suture material are used to oversew the small colon over the circumferential ligature (Fig. 23–1*F*). The small colon is returned to the abdomen. A pelvic flexure enterotomy is performed to evacuate ingesta from the large colon. Drains are placed in horses with peritonitis, and the ventral midline incision is closed. Rectal tears that can be reached per rectum should be sutured. A stomach tube is then passed up the rectum within the sleeve of the rectal liner, and the small colon is flushed gently with water and infused with 3 to 4 L of mineral oil.[7]

[h]Dexon, Davis & Geck, Inc., American Cyanamid Co., Manati, PR.

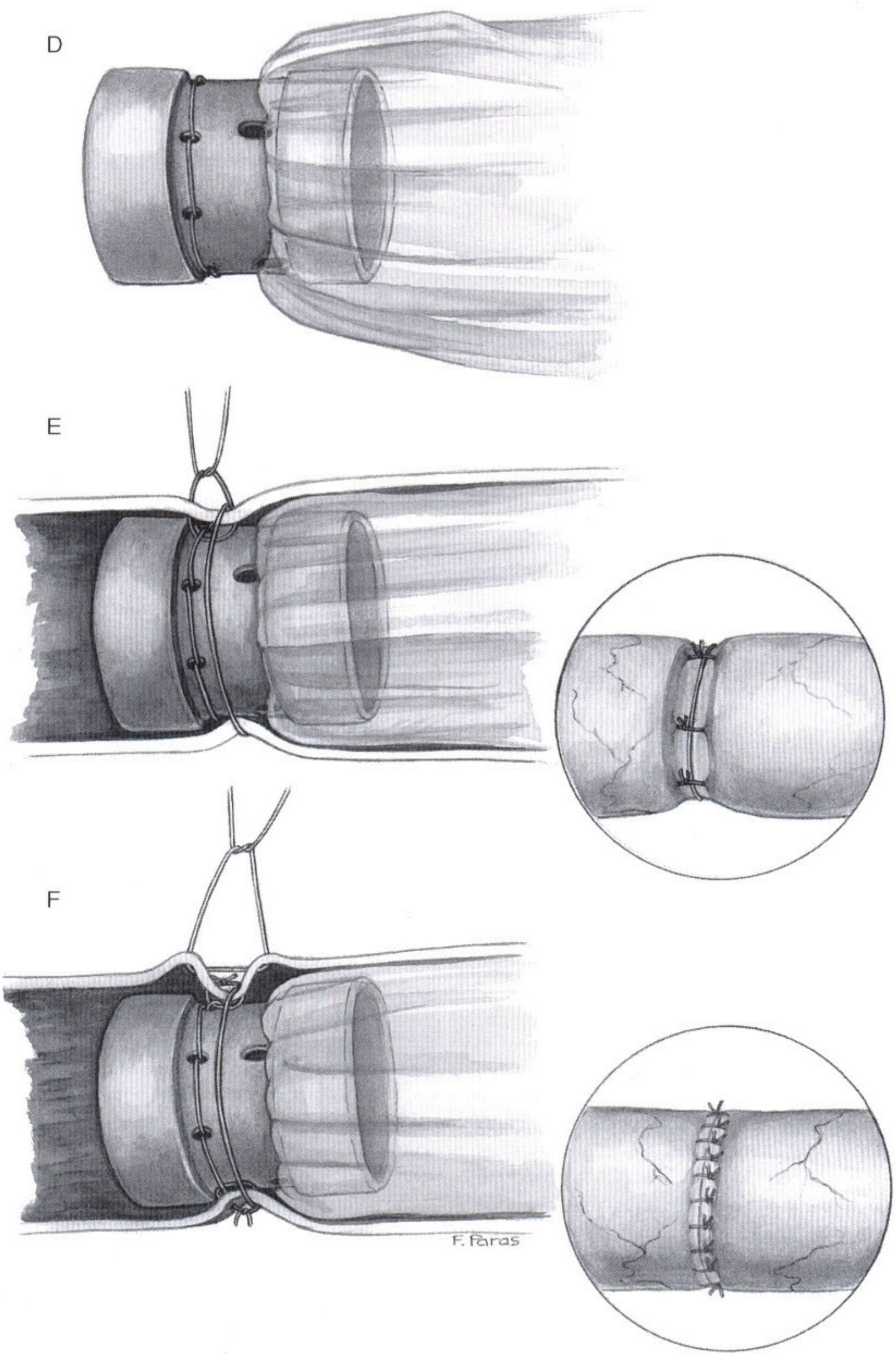
Postoperative Management

Treatment of septic shock and peritonitis with intravenous fluids, systemic antibiotics, heparin, nonsteroidal anti-inflammatory drugs, and peritoneal lavage should be implemented. Fecal volume should be reduced by feeding a complete pelleted feed, and fecal consistency is softened with mineral oil given each day until the temporary indwelling rectal liner is passed. Fecal impactions oral to the ring are common and are removed with gentle lavage per rectum using a soft stomach tube after administration of epidural analgesia. Horses should remain standing to prevent retraction of the end of the liner into the rectum. Liners generally slough out of the small colon and are passed out of the rectum between 9 and 12 days after surgery.[7] However, rectal liners may pass as early as 2 or 3 days, or the plastic sleeve may tear.[7] Rectal tears should be evaluated for healing every 2 to 3 days using gentle digital palpation or visualization via endoscopy.

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Figure 23–1. *Continued*



chapter 24

Submucosal Resection for Rectal Prolapse

Rectal prolapse is uncommon in horses compared with other domesticated large animals, but its occurrence demands urgent attention and, in most cases, surgical treatment. The specific causes of rectal prolapse may not be obvious in many cases, but it is usually associated with tenesmus. Diarrhea, parasitism, dietary changes, increased intra-abdominal pressure (as with pregnancy, parturition, and colic), and perirectal abscesses or tumors have been linked with tenesmus and prolapse.[1, 2] The role of anal sphincter tone loss, loose mucosal attachments to the rectal muscularis, and perirectal adventitial changes is unknown. The surgeon must deal with the exposed, edematous, and often traumatized or devitalized tissues while managing the underlying causes, which may be difficult to identify. Yet these causes contribute to persistent tenesmus and rectal irritation in the immediate postoperative period.

The rectum consists of two parts, the peritoneal portion (caudal small colon), which has a mesocolon, and the retroperitoneal portion (ampulla recti) within the pelvis. How much and which portion of the rectum is involved with the prolapse determine the surgical approach. A simple mucosal prolapse (incomplete) or a complete prolapse of the ampulla recti, wherein the muscularis and adventitia are displaced but not devitalized, can be managed by submucosal resection. Involvement of the peritoneal portion, which constitutes an intussusception of the small colon into the ampulla recti or to the outside through the anus, is a serious intestinal displacement that requires exploratory laparotomy to assess the extent of injury and enable repair if possible. Intussusception accompanies the active, sometimes violent second stage of labor in mares.[3] Rarely, both portions of the rectum can be involved concurrently.

Anesthesia, Positioning, and Surgical Preparation

Control of tenesmus and evacuation of the rectum are the first steps in managing the patient. Tranquilization, epidural anesthesia, and an enema with 2% lidocaine may be indicated. The initial examination must include careful palpation of the pelvic rectum, if possible, to assess tissue integrity and to ensure that there is no intussusception of the small colon into the ampulla rectum. Further trauma to the exposed tissues must be avoided, or the rectal palpation is abandoned. Before manual replacement or submucous resection, 1 quart of mineral oil[a] or a demulcent such as glycerin is placed in the rectum and small colon to protect the mucosa and to aid the passage of feces after repair. Up to 1 gallon of mineral oil is administered per os, even in cases with suspected enteritis and diarrhea. If dry, hard feces or impaction is suspected, dioctyl sodium sulfosuccinate (DOSS)[b] may be given concurrently with the mineral oil.

Surgery is best performed on the standing horse using epidural anesthesia. Small patients, such as ponies or foals, or unmanageable horses can be positioned in dorsal recumbency under general anesthesia, which provides the same anatomic orientation to the prolapsed tissues as the standing position. We prefer 0.17 mg/kg of xylazine hydrochloride[c] diluted with 3 ml 2% mepivacaine hydrochloride[d] and sterile saline to a volume of 10 ml for epidural anesthesia. These drugs require 30 minutes to take effect; preoperative preparation can be performed while waiting for anesthesia. Local anesthetic infiltration of the anal tissues may be necessary to augment the epidural anesthesia. The tail is bandaged and tied out of the field (Fig. 24–1). The perineal region is clipped, and the clipped area and exposed rectum are scrubbed with surgical soap and rinsed with a sterile polyionic solution. Harsh disinfectants such as alcohol should not be applied to the exposed rectal mucosa. Because this is a contaminated surgery, perioperative antibiotics are appropriate. Penicillin G potassium, 22,000 U/kg, is administered as an IV bolus 30 minutes before surgery and repeated again within the first 6 hours after surgery. Drapes are unnecessary, but the surgeon should don sterile gloves and use autoclaved instruments.

[a]Mineral oil 95V, The Butler Co., Columbus, OH.
[b]Dioctynate, The Butler Co., Columbus, OH.
[c]Rompun, Miles Inc., Shawnee Mission, KS.
[d]Carbocaine-V, Pharmacia & Upjohn, Kalamazoo, MI.

Simple manual replacement of the exposed rectal mucosa may be effective when the case has been identified early, when the cause is easily identified and manageable, and when good tone remains in the anal sphincter. Pursestring sutures often do not work in the horse because the feces are naturally dry and bulky and because tenesmus accompanies prolapse. Horses tend to strain against the additional anal irritation caused by a pursestring. However, these sutures may be used effectively in selected equine cases when it appears that they can be removed in 24 to 36 hours, after the mucosal edema has subsided. One-eighth-inch umbilical tape[e] should be used for the pursestring suture. The entire circumference of the pursestring suture, except for the bow knot, should be buried in the tissue, and the suture must be tied loosely to permit fecal passage.

Surgery

When the mucosa is traumatized or necrotic, either of which can occur within 24 to 72 hours of exposure, submucous resection is indicated for most incomplete and complete prolapses. This surgery is initiated by placing gentle traction on the prolapse to expose additional normal rectal mucosa and the mucocutaneous junction of the anus. Two 18-gauge, 6-inch spinal needles are inserted vertically and horizontally through skin, anal sphincter, and normal healthy mucosa to prevent retraction during surgery (see Fig. 21–1*A*).[1] Starting at the top of the prolapse as viewed by the surgeon, circumferential incisions are made in healthy mucosa at the junction of nonviable rostral mucosa and at the mucocutaneous junction. The incisions are continued for 25 to 33% of the circumference of the prolapse (see Fig. 24–1*A*). Submucosal edema precludes serious hemorrhage, but because of the hyperemia, the occasional vessel may require electrocoagulation or ligation. Combination blunt-sharp dissection with Metzenbaum scissors[f] is used to remove all nonviable mucosa at the cleavage plane between edematous submucosa and the deeper, normal muscularis. Healthy edges of mucosa are apposed with size 1 polydioxanone[g] using interrupted horizontal mattress sutures (see Fig. 24–1*A*). These sutures must be close enough and tight enough to produce a seal. The surgery is continued in a stepwise fashion, by quarters or thirds, around the circumference of the prolapse. The surgeon is cautioned against complete circumferential removal of all diseased tissues before commencing suturing. Rectal mucosa tends to tear at the crossed spinal needles in some cases, and the weight of the redundant tissues during surgery helps to prevent retraction of the margins. Using size 2–0 polydioxanone, the mucosal edges are sutured with a simple continuous pattern to further appose and seal the defect (see Fig. 24–1*B*). This pattern should be placed in three sections to avoid a stricture effect on the rectal lumen. After the retention needles are removed, the rectal tissues usually return spontaneously to a normal position. Pursestring sutures are rarely, if ever, needed to augment submucosal resection.

Intussusception of the small colon requires exploratory laparotomy for diagnostic and prognostic purposes. The small colon has a short mesocolon, and massive displacements tear the mesocolon and disrupt the vascular integrity to variable lengths of the bowel, even extending to and including the pelvic segment of the rectum.[1] Resection and anastomosis of exposed small colon without a laparotomy can be accomplished technically but invariably is followed by avascular necrosis, peritonitis, and death. Laparotomy affords an opportunity to establish the prognosis and effect surgical repair, which may be small colon resection and permanent colostomy as a salvage procedure (see Chapter 23). If laparotomy is not warranted, euthanasia should be considered.

Postoperative Management

The threats of continued tenesmus and rectal obstipation require careful monitoring after surgery. These patients cannot be operated on, turned out, and ignored. The contents of the large colon will not have been evacuated, and the passage of additional feces is an immediate insult to the suture line. Tranquilization and repeated epidurals can be used to reduce anxiety about postoperative perineal irritation and to reduce anal sphincter spasm in patients that strain. Mineral oil or DOSS per os can be repeated during the early convalescent period, even to the point of creating a laxative-induced diarrhea. Rectal impactions must be relieved when they form, but the hydration status of all patients must be maintained, particularly when the feces are dry and impaction is suspected. Oral and intravenous routes can be used for fluid administration.

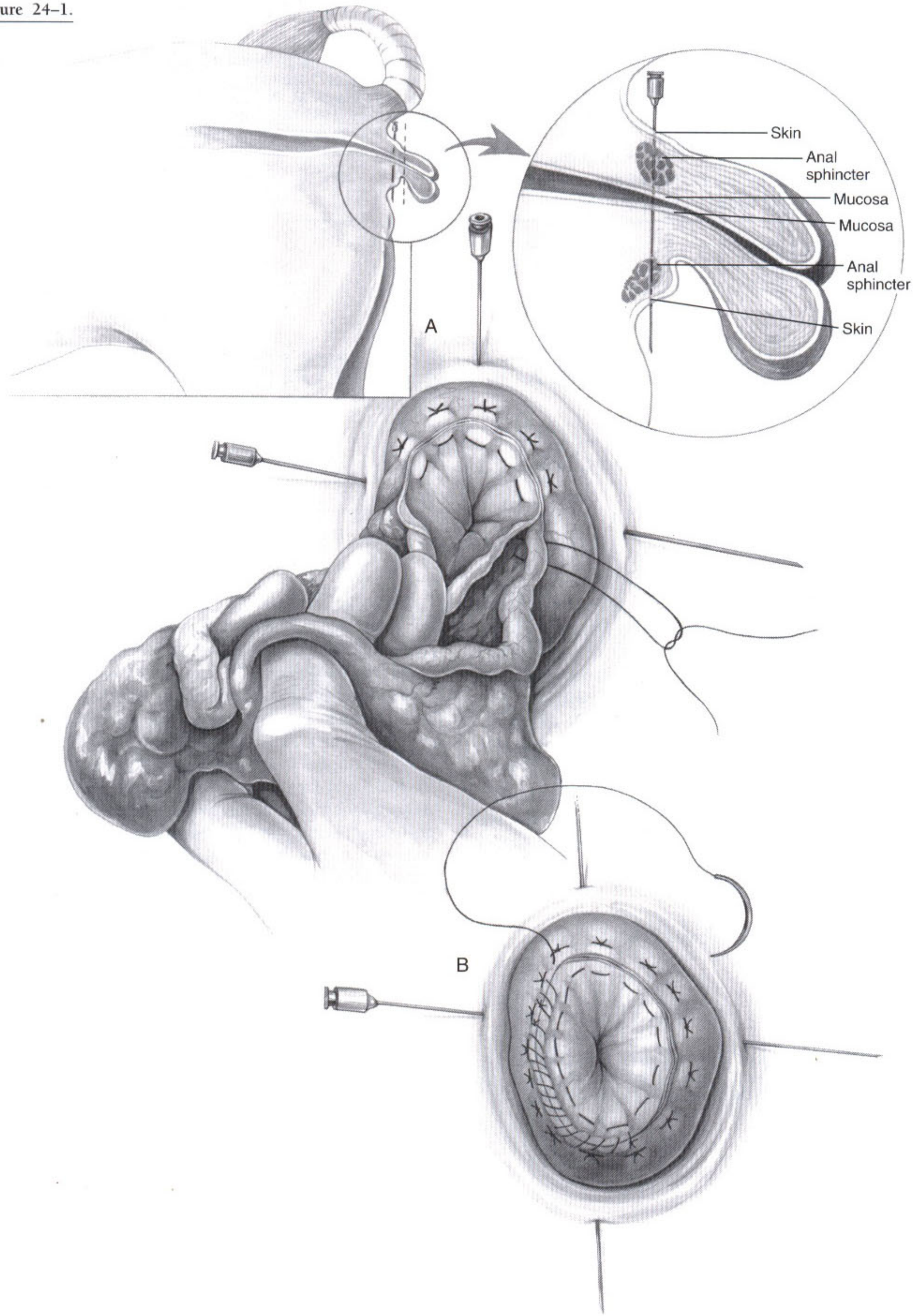
These horses should be kept standing for 3 to 5 days to help reduce the elevated pelvic pressure that accompanies recumbency. Unless a specific contraindication for feeding is known, horses benefit from feeding to normalize and maintain gastrocolic reflexes, but the type of feed selected must depend on the predisposing causes and the status of the gastrointestinal tract. Grass pasture, wet mashes, and legume hay have been used. Prolonged administration of antibiotics during convalescence is not necessary for the surgery per se but may be indicated if enteritis or another infectious process is believed to be associated with the prolapse. Tetanus vaccination status should be maintained.

[e]Cotton umbilical tape, Ethicon, Inc., Somerville, NJ.

[f]Metzenbaum dissecting scissors, Allegiance Healthcare Corp., V. Mueller, Deerfield, IL.

[g]PDS II, Ethicon, Inc., Somerville, NJ.

Figure 24–1.



The rectal mucosal stitches can be disrupted when repeated manual evacuations of the rectum are necessary during the first 3 or 4 days after surgery. However, pararectal abscesses and strictures can be avoided by careful dissection and tissue apposition and by dedicated postoperative management. Submucosal resection is the treatment of choice for rectal prolapse. The postoperative problems are manageable, and the prospects for return of the horse to normal are good.

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Respiratory Surgery

chapter 25

Excision of Nasal Epidermal Inclusion Cysts

Epidermal inclusion cysts, commonly called atheromas, occur in the caudodorsal aspect of the nasal diverticulum between the epithelium of the diverticulum and the skin of the nostril.[1] Epidermal inclusion cysts are nonpainful masses 3 to 5 cm in diameter, and they are most often unilateral. They are usually noted in horses 1 to 3 years of age, and they usually do not cause respiratory difficulty. The most common complaint is that the epidermal inclusion cyst is a blemish. Diagnosis is based on the typical location and appearance and can be confirmed by fine-needle aspiration with the identification of keratinized and nonkeratinized squamous epithelium.[2] Cysts may be lanced through the nasal diverticulum (false nostril), and the cyst lining cauterized with tincture of iodine. This method may result in recurrence. The preferable method of treatment is surgical excision.[3]

Anesthesia, Positioning, and Surgical Preparation

Epidermal inclusion cysts may be excised on the standing sedate horse using local anesthetic. General anesthesia may be used on head-shy or fractious horses. For standing surgery, the horse can be sedated with detomidine[a] or xylazine[b]-butorphanol[c] combination. The hair over the false nostril is clipped, and the skin and nasal diverticulum are surgically prepared. A surgical scrub of the diverticulum will minimize surgical contamination if it is inadvertently penetrated during dissection. Local anesthetic is infiltrated into the subcutaneous tissues in a longitudinal line 8 cm long, centered directly over the cyst. The cyst is readily identified by the bulge in the skin. The tissues surrounding the cyst should be infiltrated with anesthetic, being careful not to perforate the cyst and create weak areas, which may allow the cyst to rupture during removal. Final surgical preparation follows instillation of the local anesthetic.

[a]Dormosedan, Pfizer Inc., New York, NY.
[b]Rompun, Miles Inc., Shawnee Mission, KS.
[c]Torbugesic, Fort Dodge Laboratories, Inc., Fort Dodge, IA.

Surgery

A longitudinal skin incision up to 8 cm long, centered directly over the epidermal inclusion cyst, is made through the skin and subcutaneous tissues (Fig. 25–1*A*). Metzenbaum scissors are used for blunt and sharp dissection around the encapsulated cyst (Fig. 25–1*B*). Dissection should be done carefully to avoid rupture of the cyst, which usually has a very thin membrane. The intact cyst is removed. If the cyst is ruptured during dissection, drainage of the wound into the false nostril should be done by making a 2-cm incision from the defect into the false nostril.[4] Hemorrhage is controlled, and the subcutaneous tissue is closed with 2–0 absorbable synthetic suture material placed in a simple continuous or simple interrupted pattern. Suture bites should be taken deeply, including the tissues around the defect where the cyst was removed, helping to eliminate dead space. The skin is closed with any acceptable pattern using a noncapillary, nonabsorbable suture material (Fig. 25–1*C*). The dermis is carefully apposed to avoid a noticeable scar.

Postoperative Management

The horse should be rested for 7 to 10 days, at which time the sutures may be removed. Normal exercise can resume. Infection after surgery is rare because of the well-vascularized tissues of the nares.

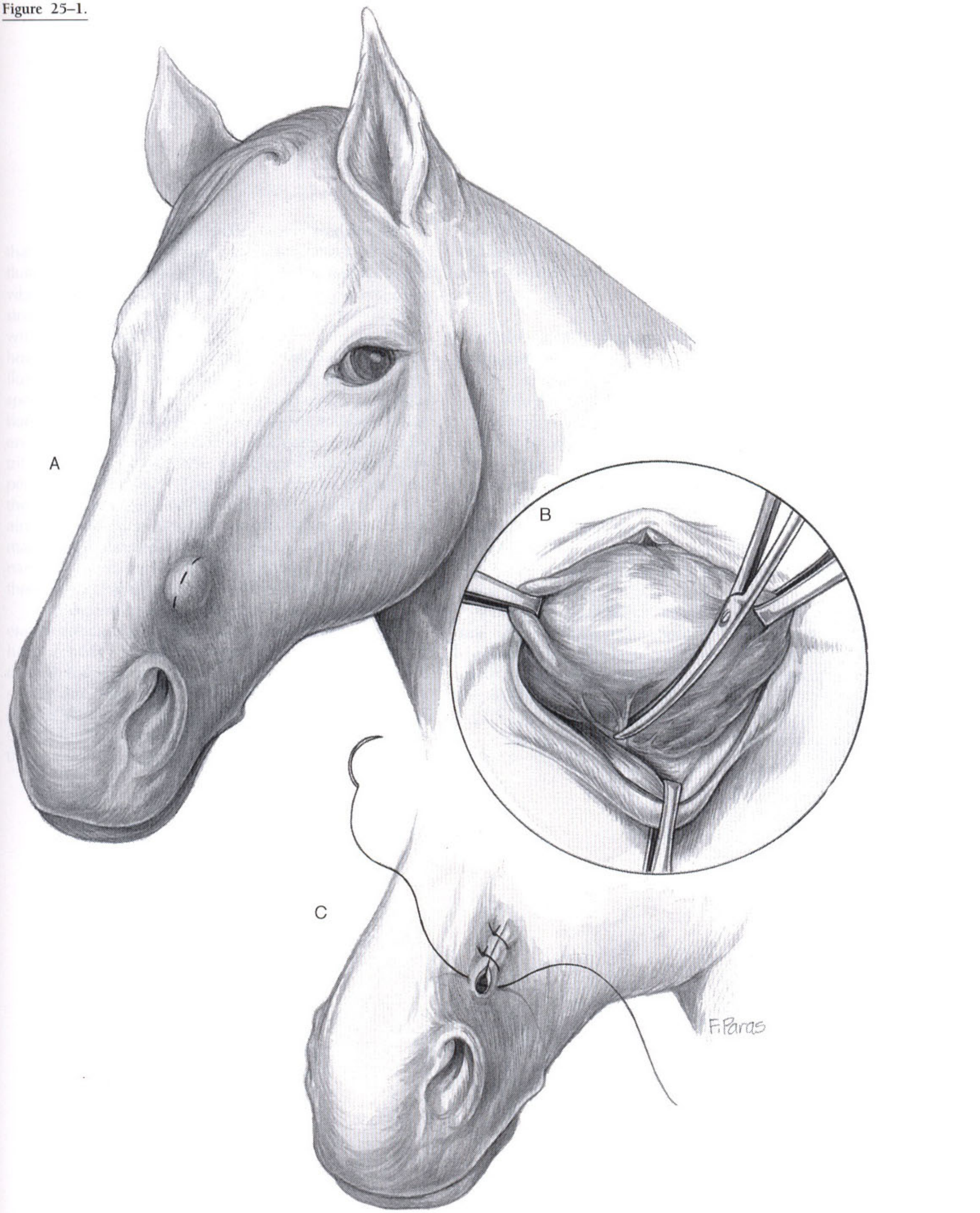
For owners particularly concerned about the presence of any noticeable scar in the skin of the nares, the cyst can be extirpated through the nasal diverticulum. This method is more difficult because of limited exposure and requires a general anesthetic with the horse positioned so the surgeon can look into the nasal diverticulum.

An alternative method for removal of epidermoid inclusion cysts is performed on the standing sedate horse with regional analgesia of the false nostril from an infraorbital nerve block. The cyst is lanced with a 1-cm stab incision into the false nostril, and a roaring bur is used to engage and evert the lining of the cyst, which is excised with scissors. The wound is left open to heal by second intention.[5]

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Figure 25–1.



chapter 26

Resection of the Alar Folds

Resection of the alar folds is indicated for horses that produce an abnormal false nostril noise or nasal flutter during exercise. The noise is a constant loud, vibrating "snore" that persists at race speeds or during strenuous exercise. The noise should not be confused with the normal nasal flutter common in pleasure horses and racehorses working slowly. Normal nasal flutter occurs on expiration only, disappears at full speed, and has been termed "high blowing." In saddle horses, false nostril noise may be objectionable to owners but may not cause exercise intolerance.[1] False nostril noise can be a cause of exercise intolerance in performance horses.[2, 3] The alar fold may be drawn into the nasal passages during inspiration, causing partial airway obstruction.[3] Horses making false nostril noise may have thickened alar folds, flaccid alar folds, small nares, or narrowed nasal passageways, but many of these horses have no anatomic abnormalities.

To determine whether the noise and exercise intolerance are caused by the alar folds and nasal diverticulum, a heavy horizontal mattress suture is placed through the skin of the nose and each alar fold, and the sutures are tied over the bridge of the nose. These sutures should be placed after instillation of local anesthetic. The sutures abduct and raise the alar folds, dilate the nares, and collapse the nasal diverticula. The horse should be exercised after suture placement. Reduction of the false nostril noise and improved exercise tolerance are indications for resection of the alar folds.

Anesthesia, Positioning, and Surgical Preparation

The horse should be anesthetized and placed in dorsal recumbency. Intubation with a cuffed endotracheal tube will reduce the possibility of aspiration of blood. The external nares and alar folds should be cleansed with a dilute surgical antiseptic. After surgical preparation, the horse's head should be tilted up in a nearly vertical position to allow the surgeon to look directly into the nostrils (Fig. 26–1*A*). This position will facilitate exposure and surgical manipulation within the nasal diverticulum.

A large Sauerbruch retractor,[a] malleable blade retractor, or similar instrument is useful to retract the external nares and skin over the alar folds during surgery. An assistant is required to hold the retractor during surgery.

[a]Sauerbruch retractor, size 2, Miltex Instrument Company, Inc., Bethpage, NY.

Surgery

The lateral margin of the true nostril is retracted from the surgical field. The alar fold is uncurled, grasped with a thumb forceps or an Allis tissue forceps, and stretched rostrally and laterally within the nasal cavity (see Fig. 26–1*A*). Using Mayo or heavy serrated scissors, the medial part of the fold is transected from just caudal to the alar cartilage to the caudal extent of the fold medial to the accessory cartilage of the ventral nasal turbinate (Fig. 26–1*B*). A second incision with the scissors is made in the shorter lateral part of the alar fold through the ventral nasal turbinate to meet the caudal aspect of the first incision (Fig. 26–1*C*). The alar fold is removed. The alar folds are very vascular, and hemorrhage will be profuse when the nasal turbinate is incised. Ligation of vessels is difficult when operating through the external nares and is not necessary. Hemostasis is achieved by suture closure of the incisions. The surgeon should be prepared to work quickly and efficiently. The incised edges of the alar fold are closed by suturing the nasal mucosa to the skin of the nasal diverticulum with a simple continuous pattern of size 1–0 synthetic absorbable suture material. Suturing should begin in the lateral aspect of the incision and progress caudally and medially to close the defect over the ventral nasal turbinate. The closure then progresses rostrally along the medially incised edge to the point at which the first incision began just caudal to the alar cartilage (Fig. 26–1*D*). One continuous strand is satisfactory. Snugly positioned suture bites 5 mm apart will control hemorrhage. Blood loss is inconsequential if surgery is expedient. The opposite alar fold is removed in the same manner.

Postoperative Management

Before removal of the cuffed endotracheal tube, the head and neck of the horse should be lowered to drain any blood that may have entered the pharynx or trachea. The cuff of the endotracheal tube can be left inflated until it is withdrawn into the pharynx to further ensure that blood is not left in the trachea. Training can resume 10 to 14 days after surgery. Healing is usually uneventful.

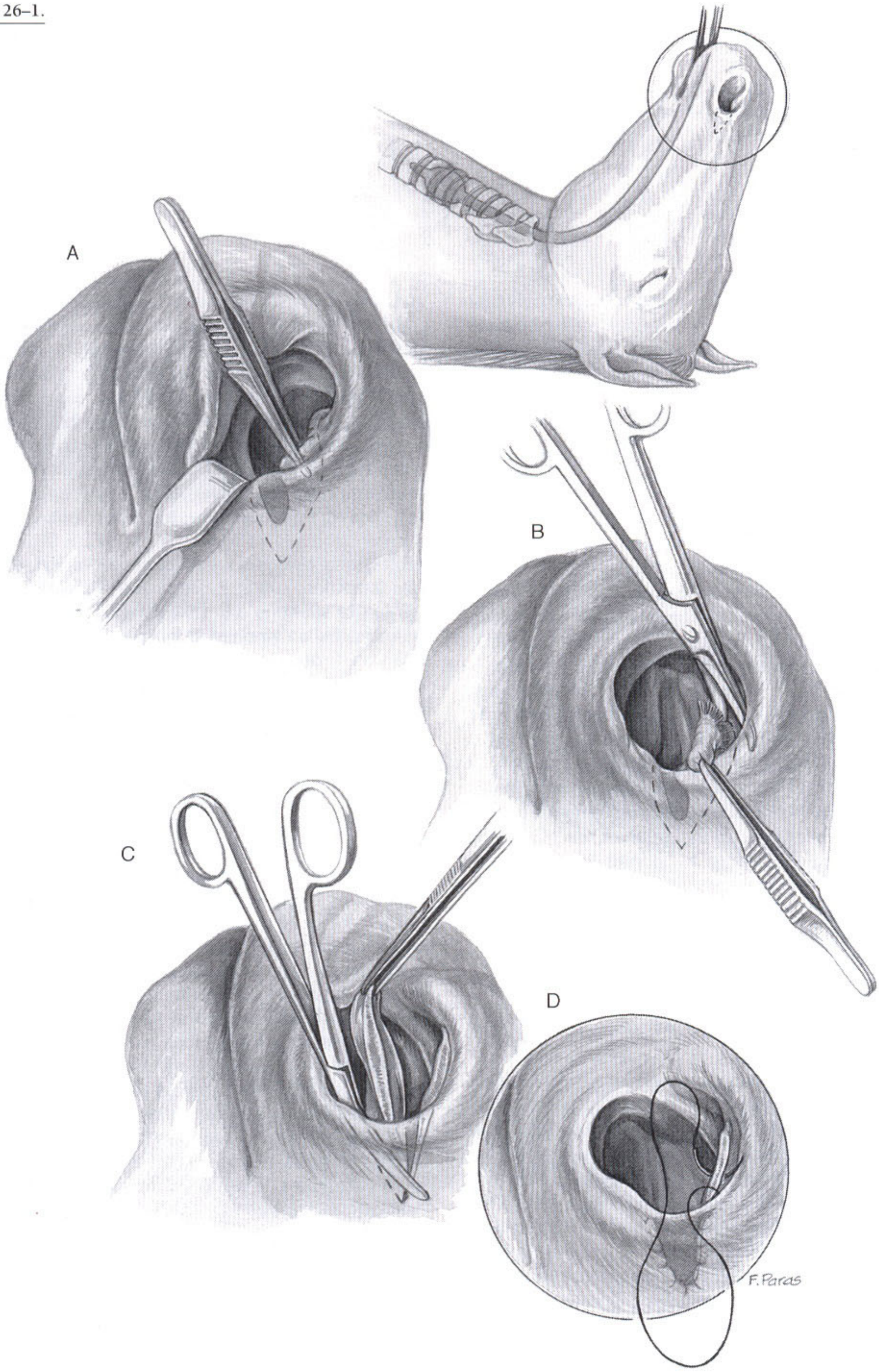
Some surgeons prefer to remove the alar folds through a skin incision that opens the lateral alae of the external nares to the caudal limit of the nasal diverticulum.[3] The incision allows improved exposure of the alar fold but may result in undesirable scar formation in the skin of the nostril.[1] Surgery time is longer because the external nares must be carefully reconstructed.

The results of surgery are usually good. False nostril noise is eliminated or reduced in nearly all cases. Performance of young racehorses with exercise intolerance can improve. In one retrospective study, performance improved in 12 of 22 horses that underwent alar fold resection, and 8 of 12 Standardbred horses improved their best time for the mile by 10 seconds or more.[2] In another study, respiratory noise was decreased and exercise intolerance improved in 10 of 14 horses.[3]

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Figure 26–1.



chapter 27

Laryngotomy and Ventriculectomy

Recurrent laryngeal neuropathy, which also has been termed *idiopathic laryngeal hemiplegia,* is a common cause of upper respiratory tract obstruction in horses. Respiratory noise during exercise and exercise intolerance are the two most common complaints. However, the disease is complex. An accurate diagnosis and the selection of proper treatment are not always simple and straightforward. Discussions of the etiopathogenesis, clinical signs, endoscopic abnormalities, diagnosis, and treatment selection are given elsewhere.[1–3]

The lateral ventricles are elongated depressions on each side of the larynx between the ventricular and vocal folds. The ventricles are the entrance to cul-de-sacs of mucous membrane, commonly called saccules, that extend dorsally and caudally for 2 to 3 cm. The saccules of mucous membrane can resonate and prolapse into the airway during inspiration in horses with laryngeal hemiplegia, causing exercise intolerance and airway noise. Ventriculectomy is performed by removing the cul-de-sacs of mucous membrane. Ventriculectomy alone does not result in improved air flow or impedance in the upper respiratory tract of horses with experimentally induced laryngeal hemiplegia.[4] However, the procedure may decrease or eliminate noise. Ventriculectomy is most often performed in conjunction with laryngoplasty. Ventriculectomy provides fibrosis and stability to the arytenoid cartilage that has been abducted by laryngoplasty. In racehorses, ventriculectomy alone is not recommended for treatment of laryngeal hemiplegia. In draft horses, unilateral or bilateral ventriculectomy is often successful for treatment of laryngeal hemiplegia.[5] In one study, 87% of draft horses were able to perform to their owners' expectations, and signs of exercise intolerance or inspiratory noise were eliminated in 80% of these horses.[5] Ventriculectomy is advantageous in draft horses; longer-duration general anesthetics necessary for insertion of a laryngeal prosthesis carry an increased risk of causing postoperative rhabdomyolysis. However, we recommend laryngoplasty and ventriculectomy in competition pulling draft horses because these horses work strenuously.

Laryngotomy is used to gain access to the lumen of the larynx, the epiglottis, and the soft palate. Laryngotomy is the surgical approach for ventriculectomy, staphylectomy, correction of an entrapped epiglottis, resection of subepiglottic cysts, arytenoidectomy, and epiglottic augmentation.

Anesthetic, Positioning, and Surgical Preparation

Laryngeal ventriculectomy can be performed with the horse standing using sedation and local anesthesia or after induction of general anesthesia. For standing surgery, the horse should be restrained in stocks and sedated, and the head raised and extended. Hair should be removed with clippers and the skin surgically prepared. Ten to 15 ml of lidocaine or mepivacaine is infiltrated into the subcutaneous tissues and ventral strap muscles down to the larynx. The anesthetic should be placed directly over the cricothyroid ligament of the larynx. After laryngotomy, additional local anesthetic is used to desensitize the mucous membrane of the cul-de-sac. On the standing horse, ventriculectomy is usually performed blindly as guided by palpation. The surgeon must be familiar with anatomy, eversion of the cul-de-sacs of mucous membrane, and instrument manipulation. We have performed standing ventriculectomy on draft horses using the videoendoscope for visualization of the surgery. This has made the procedure faster and easier, improving our confidence in removing all of the mucous membrane of the saccules.

General anesthesia is most commonly used for ventriculectomy, particularly in light horses. The horse is positioned in dorsal recumbency with the head and neck extended slightly less than maximally. The head and neck should be straight, helping to keep the incision on the midline. Endotracheal intubation of the horse with a 20-mm-diameter tube will eliminate the need to remove the tube during the ventriculectomy. A larger tube may obstruct manipulation of mucous membrane during eversion and excision, and it will need to be removed temporarily.

Self-retaining retractors to hold the laryngotomy incision open are required. Gelpi, Weitlaner, or Hobday

roaring[a] retractors are satisfactory. We prefer Hobday retractors when horses are anesthetized. However, Hobday retractors easily dislodge in the standing horse, and for standing surgery we use Gelpi retractors. Gelpi retractors must be positioned carefully to avoid excessive damage to the laryngeal mucosa. A roaring or sacculectomy bur[b] for everting the cul-de-sacs of mucous membrane is helpful and hastens surgery but is not mandatory. The bur is toothed and can be used to engage the mucous membrane and then evert it.

Phenylbutazone, 4.4 mg/kg, is administered intravenously before surgery to decrease postoperative laryngeal edema, but the efficacy is not proven.

Surgical Procedure

Laryngotomy

With the horse in dorsal recumbency, a 6-cm ventral midline skin incision is made directly over the cricothyroid ligament of the larynx. The correct location can be determined by palpation of the cricoid and thyroid cartilages, with the neck slightly flexed. In heavily muscled horses the larynx is difficult to palpate, but the center of the incision should be at the level of an imaginary horizontal line between the rami of the mandibles where they meet the muscles of the neck (Fig. 27–1*A*). The skin incision exposes the midline fascia of the sternohyoideus and omohyoideus muscles, which are split with the knife or scissors. At this point, the surgeon should identify the cricoid and thyroid cartilages, the cranial thyroid notch, and the cricothyroid membrane to ensure that the deeper incision will be in the correct location. The ventral aspect of the thyroid cartilage has a laryngeal prominence on the ventral midline that can be palpated and that demarcates the cranial aspect of the incision. Self-retaining retractors can be used to separate the muscles and the loose fascia and fat over the cricothyroid ligament. The ligament is incised in the same direction as the skin incision. Usually a small vein passing horizontally across the ligament near the cricoid cartilage will be severed. This vein can be clamped with hemostats or cauterized. The cricothyroid membrane is incised by making a quick stab incision with the scalpel blade into the larynx at the caudal aspect of the ligament immediately adjacent to the cricoid cartilage (Fig. 27–1*B*). The quick stab ensures that the underlying mucous membrane of the larynx is also incised and not pushed away from the ligament. The incision in the cricothyroid ligament is extended to the laryngeal prominence on the thyroid cartilage, and the self-retaining retractors are repositioned in the incision to hold the cricothyroid ligament open.

Ventriculectomy

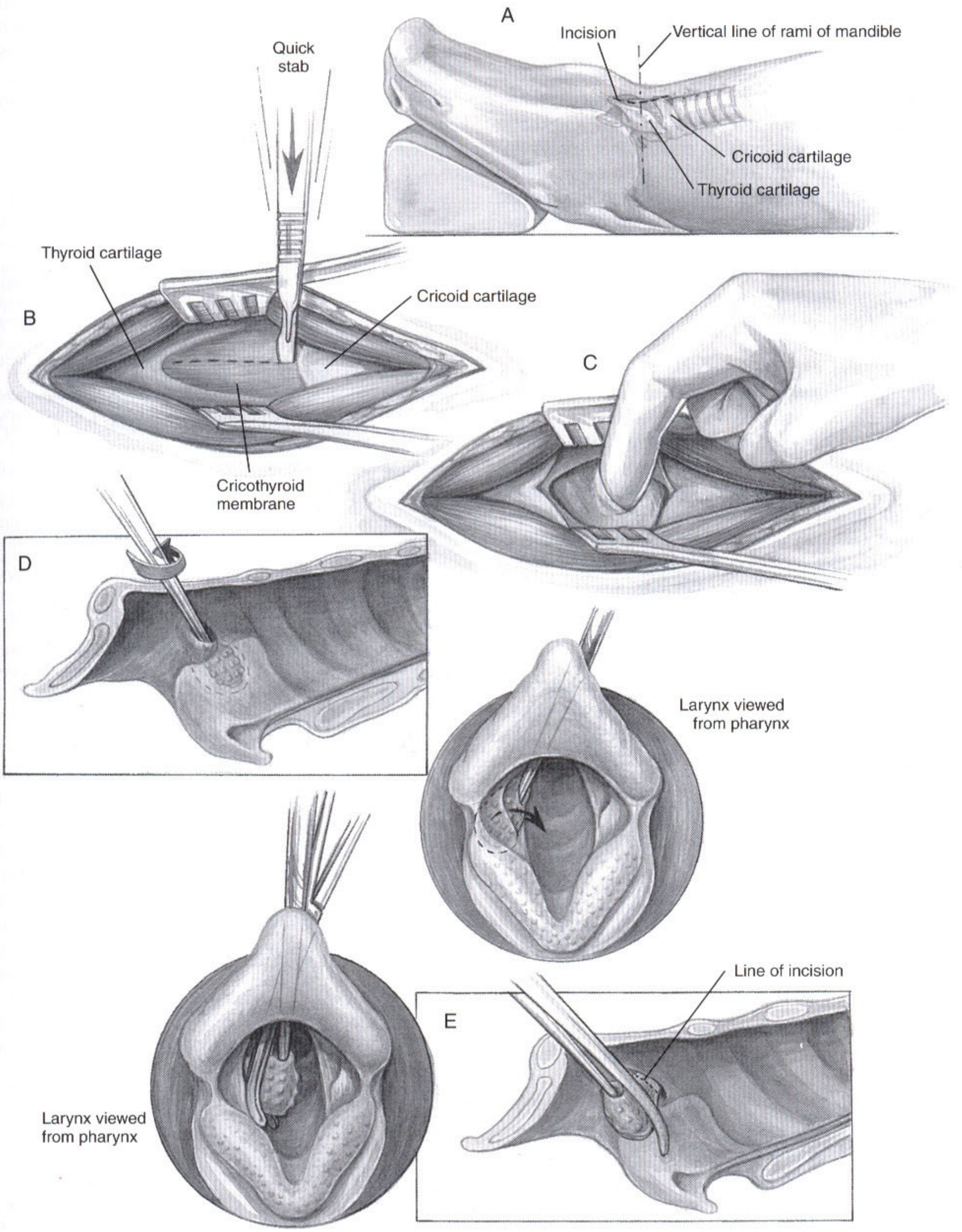
The laryngeal ventricle is identified with the index finger (Fig. 27–1*C*). It lies just cranial to the vocal fold. The finger can be inserted into the saccule by moving it laterally, dorsally, and caudally toward the base of the ear.[6] The saccule is dried with a gauze sponge on a long Allis tissue forceps. The mucous membrane is most easily everted into the larynx with a toothed roaring bur. The bur is inserted into the saccule as deeply as possible in the dorsal and caudal direction and then rotated to engage the mucosa while being pushed into the saccule (Fig. 27–1*D*). Rotation of 360 to 540° is usually sufficient to engage the mucosa. Rotation is stopped when resistance occurs. Over-rotation can cause the bur to tear through the mucosa and make eversion difficult. Once the mucosa is engaged, it is everted by slowly retracting the bur out of the ventricle. Slight derotation may be necessary as the bur is brought axially. As the mucosa is everted, it is grasped with a curved Ochsner forceps (Fig. 27–1*E*). The mucosa is unfurled and the bur removed. The mucous membrane is fully everted by using a second Ochsner forceps to alternatively cross-clamp and pull it axially. When full eversion has been achieved, no cavities will be present cranial or caudal to the everted cul-de-sac. The mucosa is excised with scissors close to the vocal fold and removed. When no bur is available, the mucosa can be everted by traction with a forceps or by incising just cranial to the ventricle and then inserting a finger through the incision lateral to the mucosa and pulling the mucosa into the laryngeal lumen with finger traction.[1] In some horses with vocal folds noted to be very flaccid before surgery, the vocal folds are excised with scissors after completion of the ventriculectomy.

Bilateral ventriculectomy is preferred when used as the sole procedure for treatment of laryngeal hemiplegia. When ventriculectomy is done in conjunction with a laryngoplasty, only the saccule on the affected side is removed. We prefer to leave the laryngotomy incision open to heal by second intention. Primary closure[7] and partial closure[8] of laryngotomy incisions have been advocated. Thorough lavage should be performed because the larynx is not sterile, and the cricothyroid ligament and mucosa should be closed meticulously.[1] The main disadvantage to closure is that no portal for quick insertion of a tracheotomy tube is available if postoperative laryngeal edema develops. Incisional complications are frequent when primary closure is performed. In one study, nearly 20% of primary closed incisions required intervention for incisional healing to occur.[7]

[a]Hobday roaring retractor, Jorgensen Laboratories, Inc., Loveland, CO.

[b]Roaring bur, Jorgensen Laboratories, Inc., Loveland, CO.

Figure 27–1.


A
Incision
Vertical line of rami of mandible
Cricoid cartilage
Thyroid cartilage
Quick stab
Thyroid cartilage
Cricoid cartilage
B
Cricothyroid membrane
C
D
Larynx viewed from pharynx
Line of incision
E
Larynx viewed from pharynx

Ventriculectomy in the Standing Horse

This procedure is performed in the same way as just described, except local anesthesia must be applied to the mucous membrane of the cul-de-sac before eversion and resection. Gauze soaked in local anesthetic and pushed into the saccule for 3 minutes is acceptable. We prefer to spray the saccule with local anesthetic using a multifenestrated infusion pipette that sprays anesthetic in all directions. This pipette can be made by heating a plastic cattle insemination pipette, pinching one end closed, and then using a hot needle to place multiple perforations in that end. The pipette is inserted into the saccule, and 4 to 5 ml of lidocaine or mepivacaine is sprayed onto the mucosa. Endoscopic visualization can be used to guide surgery.

Postoperative Management

Anesthetized horses should recover with the endotracheal tube in place. A tracheotomy tube should be kept at stallside for 3 days because laryngeal edema can develop rapidly. We confine horses to a stall for 4 weeks. Paddock rest for an additional 2 to 4 weeks is recommended. The laryngotomy incision needs to be cleaned at least twice daily, and petroleum jelly is applied to the surrounding skin for protection until wound discharges cease. Usually this occurs in 10 to 14 days. We do not routinely use perioperative or postoperative antibiotics when sacculectomy alone is performed. Phenylbutazone may be administered for 2 days.

Laryngeal ventriculectomy and ventriculocordectomy have been performed using a transendoscopic neodymium:yttrium-aluminum-garnet (Nd:YAG) laser.[9] Surgery can be performed transnasally with horses sedated and standing. Specialized equipment and training are required.

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chapter 28

Laryngoplasty

Laryngeal hemiplegia, or paresis, is usually a unilateral disease of the larynx resulting in the inability of the horse to effectively abduct the arytenoid cartilage during inspiration. This may result in exercise intolerance and exercise-induced respiratory noise. The noise made by horses with laryngeal hemiplegia is the reason they are commonly called roarers. In horses with laryngeal hemiplegia, the effect on the larynx ranges from mild subclinical paresis to complete paralysis. Clinical signs reflect the degree of dysfunction.

Laryngeal hemiplegia is common in large-breed saddle horses such as the Thoroughbred. The disease is most commonly caused by an idiopathic recurrent laryngeal neuropathy. Laryngeal hemiplegia may also be caused by recurrent laryngeal nerve damage from trauma, perivascular or perineural injections of irritating substances, mycosis of the guttural pouch, lead poisoning, and abscesses.[1] A thorough discussion of etiopathogenesis, clinical signs, and diagnosis is given in several textbooks.[1–3]

The laryngoplasty procedure consists of extralaryngeal placement of a suture prosthesis between the cricoid cartilage and the muscular process of the arytenoid cartilage. The suture abducts the collapsed arytenoid cartilage, thus enlarging the area of the rima glottidis. The prosthesis replaces the function of the cricoarytenoideus dorsalis muscle. Laryngoplasty is usually performed in conjunction with laryngeal sacculectomy to provide additional fibrosis for support of the arytenoid cartilage in an abducted position and to minimize noise production.[1] An effective laryngoplasty is currently the best method for treating horses with laryngeal hemiplegia, particularly when the horse will be used for strenuous activities and exercise intolerance interferes with performance.[1, 4]

Anesthesia, Positioning, and Surgical Preparation

Perioperative antibiotics may be administered to horses undergoing laryngoplasty because a large-sized, nonabsorbable suture material will be used for the prosthesis. We administer 22,000 U/kg of body weight penicillin G potassium intravenously before surgery and again within 2 hours after completion of surgery. Horses are also given 4.4 mg/kg of phenylbutazone intravenously before surgery to reduce possible postoperative laryngeal edema. The surgery site is clipped to remove hair before induction of general anesthesia when possible.

After general anesthesia is induced, the horse is positioned in lateral recumbency, with the affected side of the larynx uppermost. The head and neck should be extended to improve surgical access to the larynx. We do not routinely elevate the neck with padding, as has been recommended by some surgeons.[1] In our experience, elevating the neck has made retraction of the sternomandibularis muscle, linguofacial vein, and skin away from the larynx more difficult. The skin at the surgical incision is shaved. Surgical preparation of the skin and draping are routine. The use of hand-held Sauerbruch retractors[a] with a 90° angle can improve surgical access to the larynx during insertion of the prosthetic suture. However, their use requires an assistant.

Finally, before initiating surgery, the surgeon should be very familiar with laryngeal anatomy and the surgical approach.[3] Practice on cadaver horses is recommended.

[a]Sauerbruch retractor, size 2, Miltex Instrument Company, Inc., Bethpage, NY.

Surgical Procedure

Laryngoplasty

An 8- to 10-cm-long skin incision is made immediately ventral and parallel to the linguofacial vein, extending rostrally from the point at which the vein crosses the sternomandibularis muscle (Fig. 28–1*A*). The subcutaneous tissues are incised in the same plane to expose deeper fascia between the omohyoideus muscle and the vein. In the central aspect of the incision, the fascia between the vein and muscle is cut for 5 to 6 cm with scissors, leaving 3 or 4 mm of fascia next to the vein for closure. The surgeon should be careful not to damage the linguofacial vein. Occasional skin or subcutaneous bleeders can be clamped with a hemostat and electrocoagulated. The vein can be pushed dorsally and both index fingers inserted into the incision and used to bluntly dissect through the loose fascia around the larynx (Fig. 28–1*B*). The plane of dissection is expanded by blunt dissection until the surgeon can palpate the muscular process of the arytenoid cartilage, the median ridge of the cricoid cartilage, and the caudal border of the cricoid cartilage. Hemorrhage should be minimal during this dissection. At this point, dissection is more extensive in the deeper loose fascia than in the more superficial fascia between the linguofacial vein and the omohyoideus muscle, creating a funnel-shaped plane of dissection. Sauerbruch retractors can be placed in the incision underneath the vein and sternomandibularis muscle, and these structures are elevated away from the larynx by retracting dorsally and laterally.

The commissures of the subcutaneous fascia are extended by a combination of blunt and sharp dissection to allow visualization of the cricoid cartilage and the thyropharyngeus and cricopharyngeus muscles that overlie the muscular process of the arytenoid cartilage. By first having dissected deeper to this fascia, the operator can more easily identify and preserve the vessels and nerves that support the omohyoideus muscles. When exposure is limited by nerves and vessels, the fascia around them is transected with scissors to gain mobility. The vessels and nerves usually can be retracted. Ligation of vessels is rarely required. To expose the muscular process of the arytenoid cartilage, a retractor is placed in the cranial aspect of the incision, and the septum between the thyropharyngeus and cricopharyngeus muscles is split longitudinally with scissors to expose the shiny white cartilage of the apex of the muscular process (Fig. 28–1*C* and *D*). Although this septum is often depicted as being oriented in a dorsal-cranial to caudal-ventral plane, it is not always in this plane and is not always easy to identify. However, the muscular process is easily palpated, and muscle fibers split longitudinally over the process will provide sufficient exposure.

The retractor is now placed in the caudal aspect of the incision. The dorsolateral caudal border of the cricoid cartilage should be exposed by blunt separation of overlying fascia using Metzenbaum scissors. The surgeon should carefully preserve the thyrolaryngeal vascular pedicle, which can be retracted caudally during placement of the prosthesis in the cricoid cartilage. Cranial thyroid veins often lie closely apposed to the axial surface of the cricoid cartilage at the point of dissection. Damage to these veins should be avoided. They are difficult to clamp with hemostats and difficult to ligate. If a vein is inadvertently damaged, hemorrhage can often be controlled with 3 to 5 minutes of gentle counterpressure with gauze surgical sponges.

The laryngeal prosthesis consists of heavy nonabsorbable braided polyester suture material. Strands should be at least 18 inches long. The suture material can be used as a single or double strand. We prefer to use a single strand of no. 5 Ti-Cron[b] suture material for the prosthesis, but we place two separate prosthesis sutures in the larynx. Needles must be sturdy enough to penetrate cartilage. We use a half-circle no. 2 trocar point needle[c] for the bite in the cricoid cartilage and a half-circle no. 5 trocar point needle[c] for passage through the muscular process. A cutting point needle also is satisfactory. The prosthesis must be positioned to approximate the normal line of tension of the cricoarytenoideus dorsalis muscle. Tension on the muscular process must be in a caudomedial direction to abduct the arytenoid cartilage.

The prosthesis is first placed through the cricoid cartilage. To improve exposure of the dorsal aspect of the cricoid cartilage, the thyroid cartilage can be grasped with a towel clamp and rotated downward and outward. The Sauerbruch retractor should be placed in the caudal aspect of the incision. The prosthesis is inserted by depressing the soft tissues on the caudaldorsal aspect of the cricoid cartilage with the left index finger and palpating the caudal notch of the cricoid cartilage. The needle is walked off the back of the cricoid cartilage next to the notch just lateral to midline and passed under the cartilage for approximately 1.5 cm (Fig. 28–1*E*). The needle should stay close to the inner surface of the cartilage to avoid penetration of the underlying laryngeal mucosa and inadvertent entrance into the airway. The needle is then forced through the cricoid cartilage. Penetration of the cartilage may be difficult. The surgeon should roll the needle holders and drive the needle along its circular arc to avoid bending or breakage of the needle. The needle should pass in a craniomedial direction, with the point emerging 4 to 5 mm caudal and lateral to the midline ridge of the cricoid cartilage. This ridge is easily palpated as a cartilaginous spine on midline. The needle point is guarded to avoid damage to the esophagus or common

[b]Ti-Cron, Davis & Geck, Inc., American Cyanamid Co., Manati, PR.

[c]Anchor needles, Owens and Minor, Indianapolis, IN.

Figure 28–1.

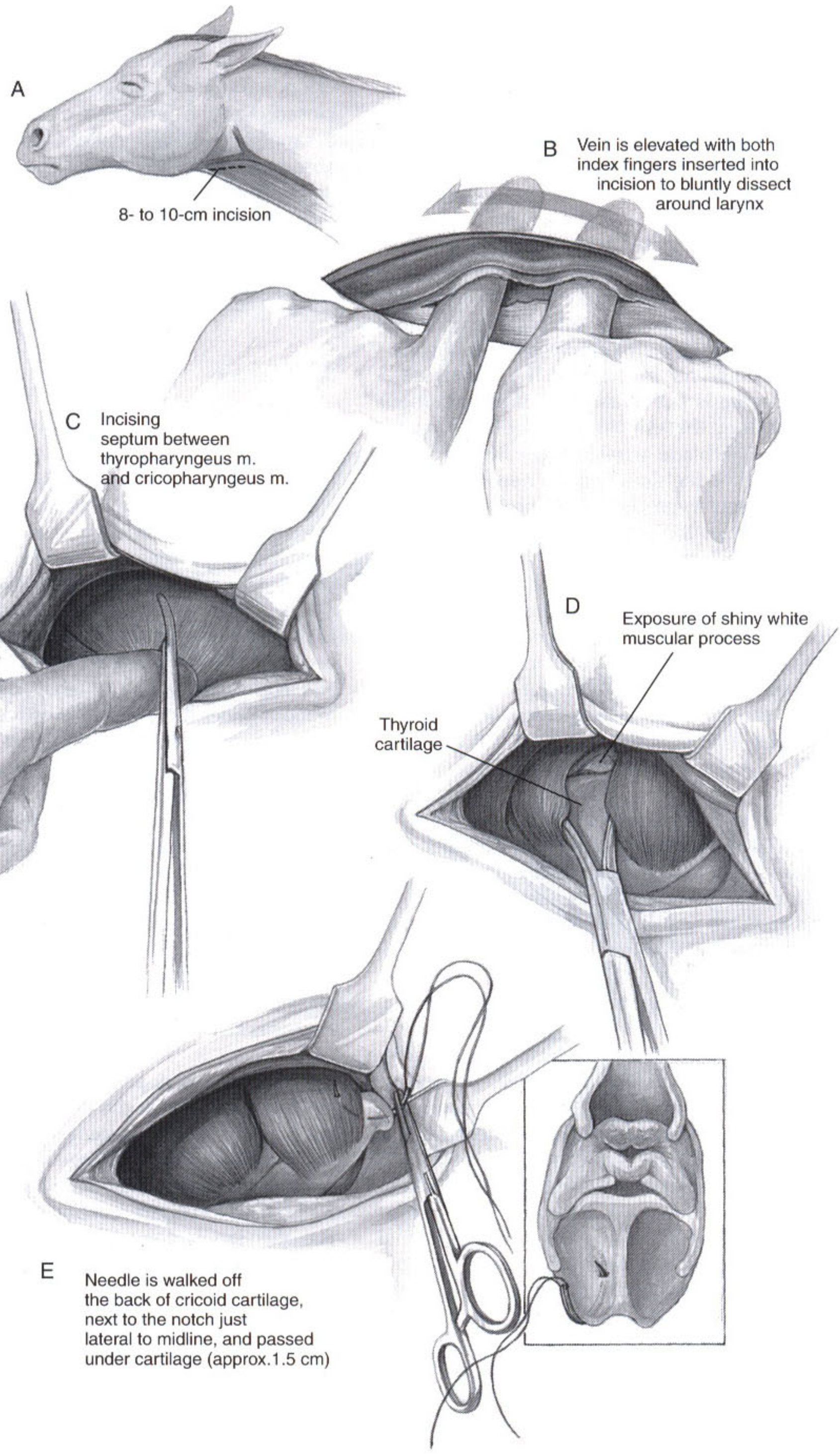


Illustration continued on page 149

carotid artery. The most common mistake is to place the prosthesis too far laterally through the cricoid cartilage. This will result in the prosthesis' being in a position to pull the muscular process caudally instead of caudomedially, creating adduction of the arytenoid cartilage instead of the desired abduction.[1]

Once the prosthesis is anchored in the cricoid cartilage, the ends are brought out of the incision and the needle is removed. The suture is pulled back and forth gently to ensure that it has engaged the cricoid cartilage and is not restricted from sliding as it is tied. A curved forceps is bluntly introduced from cranial to caudal under the cricopharyngeus muscle to separately grasp both ends of the prosthesis and pull them forward so they are adjacent to the muscular process (Fig. 28–1*F*). The ends should not be crossed. The smaller no. 5 trocar point needle is put on the end of the prosthesis that emerged from the cricoid cartilage next to the midline ridge. The blade retractors are moved to the cranial aspect of the incision, and the needle is passed through the muscular process in a medial to lateral direction. Passage of the needle may be difficult, and the surgeon should insert and retrieve the needle along its arc to avoid breakage. The needle should pass through the muscular process just cranial to the apex to ensure that the prosthesis is placed solidly in the cartilage (Fig. 28–1*G*). The surgeon should avoid placing the prosthesis more than 5 mm cranial to the apex because the caudomedial leverage on the muscular process, needed to abduct the arytenoid cartilage, will be reduced, possibly resulting in inadequate abduction.

The needle is removed, and the prosthesis is pulled gently back and forth through the muscular process to ensure that it will slide when tension is applied. After ensuring that the prosthesis suture strands are not twisted, the ends are tied under tension. The amount of tension is subjective. We tie the ends as tightly as possible using one index finger on each strand. The index fingers are positioned against the larynx so that tension in the prosthetic suture is aligned with the original pull of the cricoarytenoideus dorsalis muscle. Braided polyester suture material has poor knot security, so clamping the first throw of the knot with hemostats is necessary to avoid slippage while the second throw is placed. A secure knot will require four or five throws. The surgeon strives to abduct the arytenoid cartilage to a position midway between full abduction and the resting position.[5] Endoscopic evaluation of the arytenoid cartilage during surgery can determine whether abduction has occurred but is unreliable in determining the amount of abduction that will be achieved after the horse has recovered from anesthesia.[1] We routinely evaluate arytenoid abduction intraoperatively for horses with repeat laryngoplasty or when we suspect arytenoid chondritis is present.

A second prosthesis is placed in a manner identical to the first. It is placed just lateral to the first prosthesis in the cricoid cartilage and just cranial to the first prosthesis in the muscular process (Fig. 28–1*H*). The cricopharyngeus and thyropharyngeus muscles are closed over the prosthesis and muscular process with a simple continuous pattern using size 2–0 synthetic absorbable suture material. The same suture material and pattern are used to close the fascia adjacent to the linguofacial vein, the omohyoideus muscle, and the subcutaneous tissues. The skin is closed with size 2–0 synthetic nonabsorbable suture material in any suitable pattern or with staples.

Sacculectomy

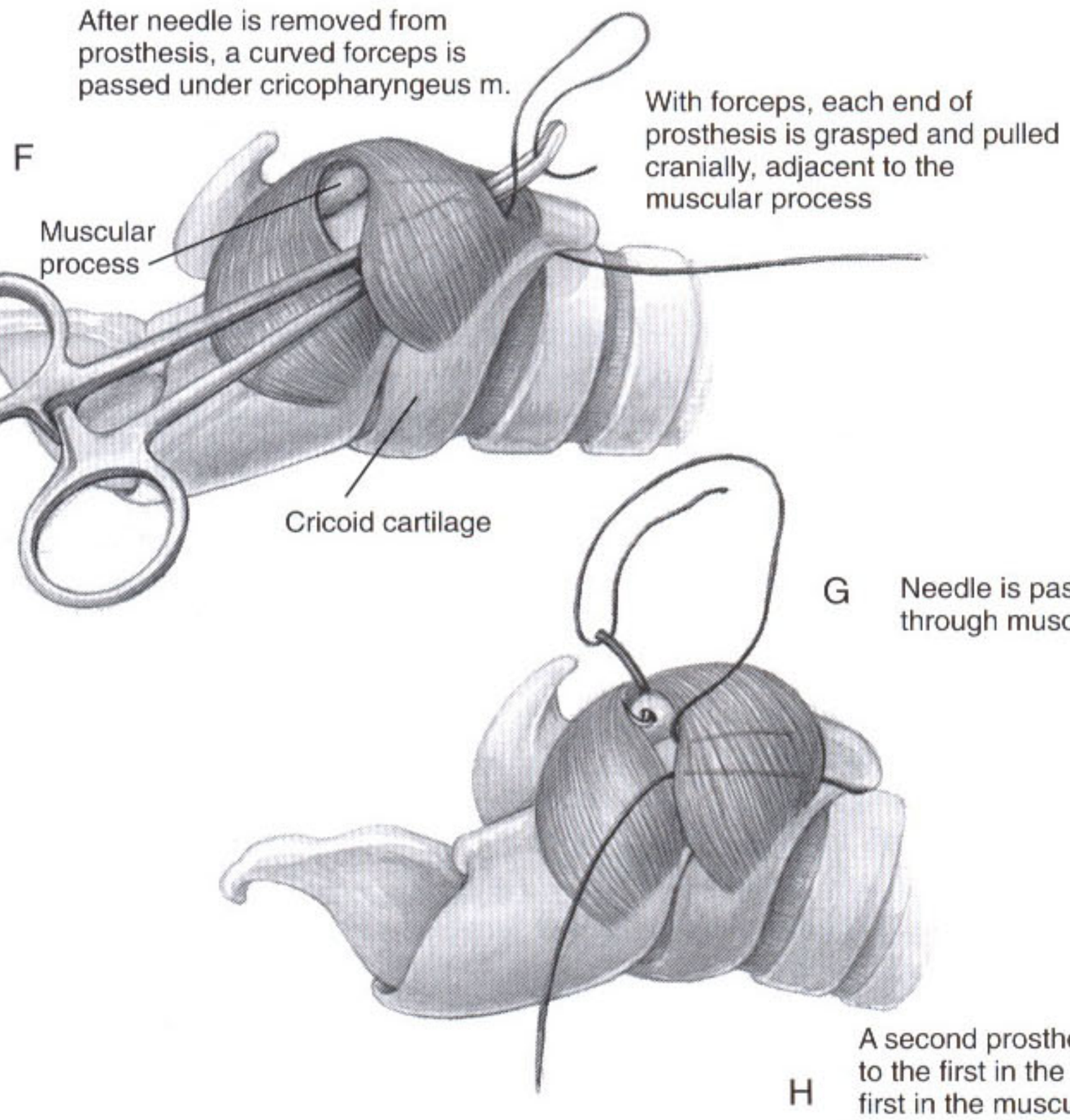
After completion of the laryngoplasty, the horse is positioned in dorsal recumbency for routine laryngotomy and sacculectomy (described in Chapter 27). Upon entrance into the lumen of the larynx, the mucosa over the cricoid cartilage is examined to determine whether the prosthesis has penetrated the mucosa. Penetration is not common but can lead to fistulas around the prosthesis as a result of contamination from the airway. If the mucosa has been penetrated, two options are available: the surgeon can (1) remove the prosthesis and replace it with a different one or (2) incise the mucosa under the exposed prosthesis, allowing it to be buried in the correct position next to the cricoid cartilage. After lavage, the incised mucosa can be closed with several interrupted sutures of size 3–0 absorbable synthetic suture material. Sacculectomy is performed. If a sacculectomy was done previously, the healed opening of the ventricle is incised and any remaining mucosa removed. The scar tissue between the arytenoid cartilage and thyroid cartilage is severed with scissors to allow full abduction of the arytenoid cartilage.

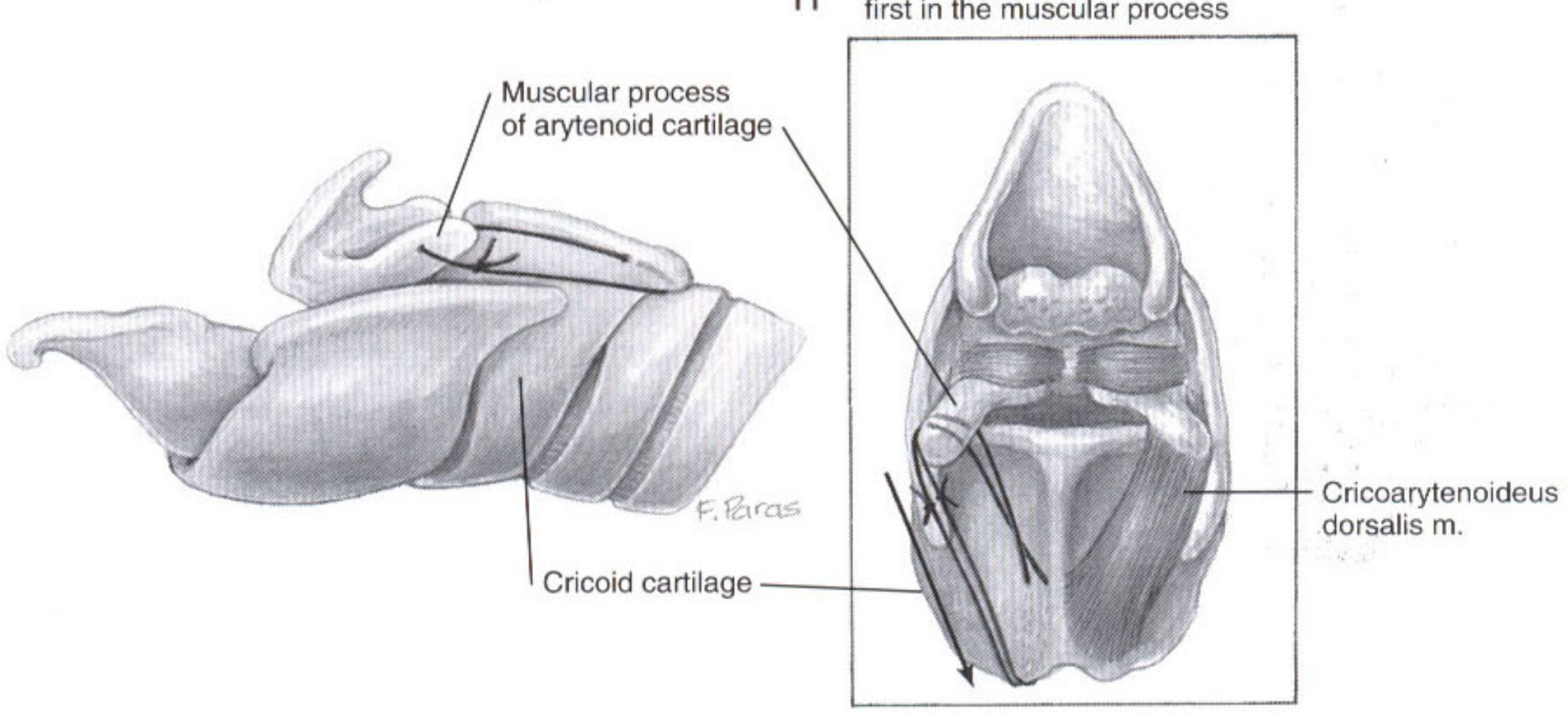
Postoperative Management

Usually, perioperative antibiotics are limited to the first 24 hours. If the prosthetic suture has entered the laryngeal lumen, systemic antibiotics are continued for 7 to 10 days. At the surgeon's discretion, phenylbutazone, 4.4 mg/kg, may be given twice daily for 24 to 48 hours. Horses are confined to a stall for 4 weeks. The open laryngotomy incision should be cleaned twice daily, and skin sutures in the laryngoplasty incision are removed after 7 days. An additional 4 weeks of rest in a small paddock is recommended before resumption of training.

Many complications have been reported as a direct result of laryngoplasty,[1, 5–7] including failure to maintain abduction, coughing, nasal discharge, dyspha-

Figure 28–1. *Continued*





gia, chondritis, wound infection and dehiscence, fistulas, tracheitis, suture sinus associated with a contaminated prosthesis, pneumonia, laryngeal edema, and intralaryngeal granulomatous polyps. Most complications are very uncommon when the surgery is performed by experienced surgeons. Coughing and nasal discharge of food and water are the most frequent complications. Coughing is associated with eating and is believed to be caused by an incompetent laryngeal seal. Full arytenoid abduction or hyperabduction increases the risk of coughing. Coughing is reported to occur in up to 57% of horses immediately after surgery and remains a chronic problem in 4 to 26%.[1, 5–7] Horses that cough should be fed on the ground to reduce contamination of the trachea.

Although maximal opening of the rima glottidis is not obtained with laryngoplasty, the procedure is effective in restoring air flow and tracheal pressures to normal baseline levels in horses with experimentally induced hemiplegia.[8] Laryngoplasty and sacculectomy are successful in improving performance and reducing respiratory noise in 25 to 90% of horses.[1, 4, 5, 7, 9] The wide range in success rates is due, in part, to the subjective nature of assessment, differences in age and breed, and the different levels of exercise expected from different groups of horses after surgery. In one retrospective study of 230 racehorses (174 Thoroughbreds and 56 Standardbreds), 77% of horses raced after surgery and 56% of horses improved their postoperative racing performance.[7] Racing Thoroughbred horses older than 3 years appear to have the least favorable prognosis.[9] Draft horses have a good prognosis.[9] For racing horses with laryngeal hemiplegia, a combined treatment of laryngoplasty and sacculectomy is preferred.

When laryngoplasty has failed, the operation can be successful when repeated in some horses.[6] Dissection to expose the muscular process and cricoid cartilage is more difficult, and the muscular process must be freed from surrounding scar tissue and from the wing of the thyroid cartilage. Partial arytenoidectomy is an alternative for the treatment of horses with failed laryngoplasty.[10]

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chapter 29

Arytenoidectomy

Arytenoidectomy was described for the treatment of horses with laryngeal hemiplegia more than 100 years ago. Because of numerous complications, arytenoidectomy was replaced first by sacculectomy and more recently by laryngoplasty for the treatment of laryngeal hemiplegia. Arytenoidectomy has been performed for the treatment of horses with arytenoid chondropathy or with laryngeal hemiplegia in which laryngoplasty has failed.[1] Other indications for arytenoidectomy include chondroma, ossification of the arytenoid cartilage, neoplasia, and treatment of very large draft horses with complete (Grade IV) laryngeal paralysis for which prolonged general anesthesia for insertion of a laryngeal prosthesis may be contraindicated. The purpose of arytenoidectomy is to improve air flow, which has been restricted by enlarged arytenoid cartilages or by cartilages collapsed into the airway secondary to laryngeal hemiplegia.[1] Numerous methods of arytenoidectomy have been performed in an attempt to provide maximum air flow with minimal complications. No procedure has become a clear favorite among surgeons.

The two most common techniques currently used for arytenoidectomy are the partial arytenoidectomy and subtotal arytenoidectomy.[2, 3] Partial arytenoidectomy is performed by resecting the entire arytenoid cartilage except for the muscular process. Because the apex of the arytenoid cartilage, also termed the corniculate process, is removed, partial arytenoidectomy has been termed corniculoarytenoidectomy.[4] Subtotal arytenoidectomy is performed by removing the base of the cartilage, leaving the muscular process and the corniculate process in place. Retention of the corniculate process in the subtotal technique maintains the contour of the piriform recess, which aids deglutition. For this reason, subtotal arytenoidectomy may be associated with less postoperative coughing and dysphasia than partial arytenoidectomy.[1, 5] Both techniques have been reported to restore exercise tolerance in performance horses.[1, 5–7] Subtotal arytenoidectomy may have fewer complications, but one experimental study demonstrated that subtotal arytenoidectomy had no beneficial effect on air flow in horses with induced laryngeal hemiplegia.[8] In one case report, subtotal arytenoidectomy to treat failed laryngoplasty in a Standardbred racehorse resulted in dynamic collapse of the corniculate process during exercise.[9] In another study, subtotal arytenoidectomy improved airway pressures in two horses with arytenoid chondritis but did not return airway pressures to normal limits.[10] In another experimental study, partial arytenoidectomy improved but did not completely restore normal upper airway function in intensely exercised horses after induced left laryngeal hemiplegia.[11] However, the authors of this study supported the use of partial arytenoidectomy for treatment of failed laryngoplasty and arytenoid chondropathy.

Most surgical reports of subtotal and partial arytenoidectomy describe preserving the mucosa overlying the axial surface of the arytenoid cartilage followed by suture closure of the mucosa after the cartilage has been removed. Dissection of the mucosa from the cartilage can be tedious and time-consuming. In our experience, preservation of mucosa is very difficult or impossible when the arytenoid cartilage and overlying mucosa are diseased from arytenoid chondropathy. However, arytenoidectomy can be performed successfully without mucosal closure.[12] The defects created by partial arytenoidectomy without mucosal closure heal without complications in 16 weeks.[12] This compares with healing of the arytenoidectomy defect in 8 weeks when the mucosa is sutured.[12] We usually perform arytenoidectomy in draft horses without mucosal closure because the surgery can be done very quickly, thereby reducing anesthetic risk.

Unilateral arytenoidectomy is most often performed. Bilateral arytenoidectomy should be considered as a salvage procedure for horses that are dyspneic at rest or after light exercise.

Anesthesia, Positioning, and Surgical Preparation

Perioperative antibiotics and phenylbutazone are administered. We prefer intravenous penicillin G potassium, 22,000 U/kg, just before surgery and immediately after recovery. Before induction of anesthesia, the neck and throatlatch should be clipped and shaved in preparation for a ventral midcervical tracheotomy incision. Dyspneic horses should have a tracheotomy tube placed before induction of anesthesia. In all other horses, the endotracheal tube is inserted via a tracheotomy performed after induction of anesthesia. Insertion of the endotracheal tube via tracheotomy keeps the

tube from interfering with surgery in the larynx. Horses are anesthetized and placed in dorsal recumbency. Routine skin preparation for a laryngotomy is performed. Self-retaining Gelpi or Weitlaner retractors are necessary. A roaring bur can be used for the sacculectomy but is not necessary. A small periosteal elevator[a] or septum elevator[b] should be available to aid in separation of the mucosa from the arytenoid cartilage. The use of heavy curved Mayo scissors or bone-cutting forceps[c] is necessary to transect the muscular process.

Surgical Technique: Modified Partial Arytenoidectomy

A routine laryngotomy (see Chapter 27) is performed. Exposure can be improved by placing two Gelpi or Weitlaner retractors, one at the cranial aspect and one at the caudal aspect, in the laryngotomy incision. We do not routinely incise the cricoid cartilage, but the body of the thyroid cartilage may be incised on midline when needed for additional exposure. The thyroid cartilage may be ossified and difficult to split; heavy scissors or a sharp bone-cutting forceps may be necessary. The surgeon should be careful not to damage the epiglottis while incising the body of the thyroid cartilage. The laryngeal saccule is removed on the affected side in a routine manner. When the mucosa over the arytenoid cartilage will be sutured, a vertical incision through the mucosa over the corniculate process is made from the apex to the ventral surface of the cartilage.[1] This incision is continued caudally along the ventral aspect of the arytenoid cartilage and then dorsally at the caudal aspect of the cartilage, forming a large U-shaped flap of mucosa (Fig. 29–1*A*). The mucosa is elevated from the cartilage with the periosteal or septal elevator (Fig. 29–1*B*). The granular mucosa overlying the corniculate cartilage should be preserved to leave a ridge of tissue in the pharynx that maintains the piriform recess. The mucosa of the corniculate process is thick and may have a very thin strip of cartilage within it. The surgeon should not transect the transverse ligament in the dorsal aspect of larynx during the dissection. The arytenoid cartilage is grasped with a forceps and pulled axially and forward. The surgeon uses scissors to free the abaxial side of the cartilage from the musculature. Bleeding is controlled with digital pressure, electrocautery, or dilute epinephrine solution. Dissection should stay as close to the cartilage as possible. The muscular process is transected with heavy curved Mayo scissors or the bone-cutting forceps, and the arytenoid cartilage is removed (Fig. 29–1*C*).

The incised edge of the corniculate mucosa is sutured laterally to the soft tissues with a few interrupted sutures of size 3–0 synthetic absorbable suture material.[1] The U-shaped mucosal flap is closed with simple interrupted sutures of the same material (Fig. 29–1*D*). Care should be taken to avoid pulling the corniculate mucosa caudally in an effort to streamline the airway. This may result in an increased contamination of the airway with food and water during swallowing. The defect in the laryngeal mucosa ventrally, where the laryngeal saccule was removed, is left open to allow drainage.

When the mucosa of the arytenoid cartilage will not be closed because of surgeon preference or because of pathologic change, the cartilage and mucosa are resected together, leaving a mucosal defect that can be left open to heal by second intention. No attempt should be made to pull the rostral corniculate and pharyngeal mucosa caudally to cover the defect. This will distort and flatten the rostral ridge of mucosa and eliminate the piriform recess. Excising mucosa shortens the surgery time, eliminating the need to elevate and suture mucosa. Submucosal hematomas are unlikely to form when mucosa is removed.[12]

The mucosa in the dorsal laryngeal region should be preserved to prevent the healing together of opposing wound surfaces when bilateral arytenoidectomy is performed. Otherwise, a web of scar tissue in the dorsal larynx may form, which can obstruct air flow.

The laryngotomy incision is left unsutured. The horse should recover with the cuffed endotracheal tube left inserted through the tracheotomy incision to ensure a patent airway during recovery and to reduce the amount of blood entering the lower airways. After the horse is standing, the tube is retracted with the cuff inflated to the level of the tracheotomy incision and then replaced with a tracheotomy tube. We routinely maintain a tracheotomy tube for 36 hours or longer to rest the laryngeal area. The tracheotomy tube should not be removed until there is endoscopic confirmation of an adequate airway and the horse can breathe easily with the tube temporarily occluded. Laryngeal swelling may be significant for up to 10 days.

Postoperative Management

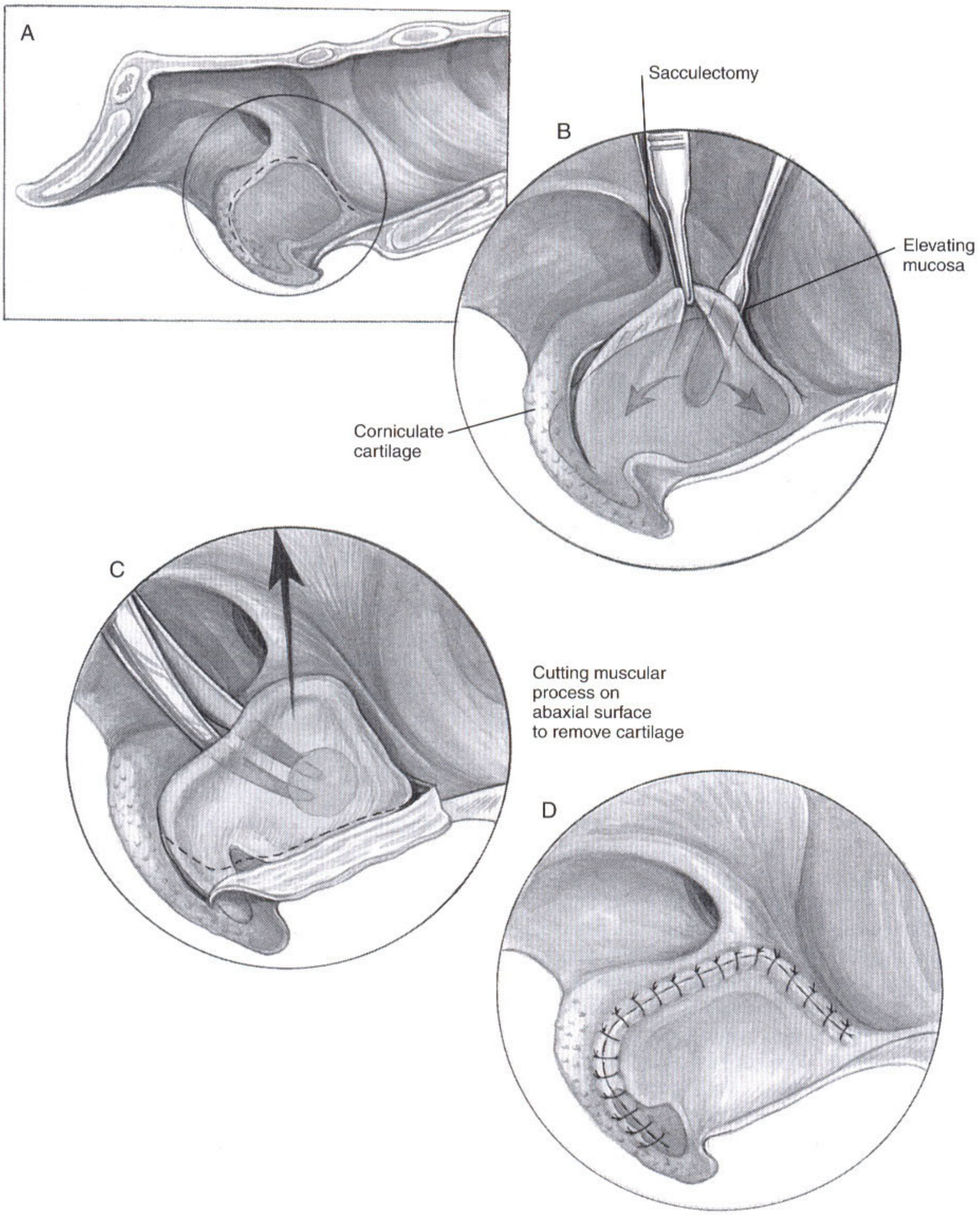
Penicillin or a trimethoprim-sulfonamide drug combination at standard dosages is given for 3 days after surgery. An anti-inflammatory drug such as phenylbutazone is given to control pain, swelling, and laryngeal edema for at least 3 days or longer depending on the degree of swelling as determined endoscopically. The laryngotomy wound should be cleaned two or three times per day, and the tracheotomy tube should be removed and cleaned daily. Horses are confined to a stall for 4 weeks. If healing is satisfactory, they can

[a]Delicate elevator, double-ended, Sontec Instruments, Englewood, CO.

[b]Freer septum elevator, Miltex Instrument Company, Inc., Bethpage, NY.

[c]Liston bone cutting forceps, Miltex Instrument Company, Inc., Bethpage, NY.

Figure 29–1.


A
B
Sacculectomy
Elevating mucosa
Corniculate cartilage
C
Cutting muscular process on abaxial surface to remove cartilage
D

be turned out to pasture for an additional 4 to 12 weeks. Horses with mucosal defects left to heal by second intention require up to 16 weeks for healing.[12] Training can be resumed in as little as 8 weeks for horses with sutured mucosal defects.

Immediately after surgery, laryngeal edema, cellulitis, and submucosa hematoma formation can cause laryngeal swelling and dyspnea. These complications usually resolve, and in the interim the dyspnea is managed with a tracheotomy tube. Coughing, dysphagia, nasal discharge of food and water, and aspiration of food materials are the most significant long-term complications. These problems occur as a result of loss of a competent laryngeal seal during swallowing and loss of the piriform recess, which, when intact, channels food and water lateral to the larynx. An incompetent laryngeal seal may be mild and cause no problems other than coughing during eating, or the incompetence may be severe, resulting in copious nasal discharge of food and water and, in some instances, aspiration pneumonia. Many horses can tolerate some degree of dysphagia and perform successfully.[1]

The likelihood of a return to racing or other performance activities appears to be approximately 50% for unilateral arytenoidectomy.[1, 13] Complications related to dysphagia are frequent.[1] Partial arytenoidectomy may be more apt to cause dysphagia than the subtotal arytenoidectomy technique.[5] However, the modification of the partial arytenoidectomy, whereby the cuff of corniculate mucosa is maintained, may reduce dysphagia to levels similar to those associated with the subtotal procedure.[1] Arytenoidectomy is believed to be more successful for treatment of arytenoid chondritis than for treatment of failed laryngoplasty.[1] Bilateral arytenoidectomy should be considered a salvage procedure.

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chapter 30

Treatment of Intermittent Dorsal Displacement of the Soft Palate

Intermittent dorsal displacement of the soft palate causes abnormal respiratory noise and exercise intolerance in horses during strenuous physical activities. The disease is most common in racehorses.[1] Displacement occurs during exercise, and the abnormal noise has an immediate onset and sounds like a rattling, gurgling, or snoring in the throat on both inspiration and expiration. Horses working at speed usually slow down quickly because of decreased air flow. Owners of racehorses often indicate that the horse "choked" or "swallowed the tongue" during the race.

Many factors contribute to intermittent dorsal displacement of the soft palate. The soft palate forms the caudal ventral free border of the opening in the nasopharynx called the ostium intrapharyngium. This circular opening seals tightly around the larynx to maintain a smooth laryngopalatal seal during respiration. Factors that produce an elevation of the soft palate or retraction of the larynx disrupt the seal and result in laryngopalatal dislocation and dorsal displacement of the soft palate.[2] Retraction of the tongue causes caudal displacement of the larynx and pushes the soft palate up. Vigorous contraction of the sternothyrohyoideus and omohyoideus muscles during inspiration can result in caudal retraction of the larynx.[3] The soft palate may be drawn dorsally by negative pharyngeal pressure during inspiration or by open-mouth breathing, swallowing, or coughing during exercise. Flexion of the head causes relaxation and narrowing of the nasopharynx, which impedes air flow and increases negative pharyngeal pressures. Dorsal displacement of the soft palate during exercise may also occur secondary to pharyngeal inflammation, epiglottic entrapment, recurrent laryngeal neuropathy, arytenoid chondritis, and soft palate paresis. Diseases such as bronchitis, tracheitis, and pneumonia that elicit coughing may also predispose to intermittent dorsal displacement of the soft palate. Epiglottic hypoplasia or flaccidity may contribute to intermittent dorsal displacement of the soft palate. A normal epiglottis is sufficiently rigid to maintain its shape, physically preventing dorsal displacement of the soft palate during exercise, despite negative pressures in the nasopharynx.[4] A hypoplastic or flaccid epiglottis is incapable of maintaining normal anatomic relationships with the soft palate, particularly during maximal exertion, and contributes to dynamic collapse of the pharynx and dorsal displacement of the soft palate.

The epiglottis should be evaluated by endoscopy and radiology for abnormalities in horses with intermittent dorsal displacement of the soft palate.[5, 6] The term *hypoplasia* is used to refer to the following abnormalities when visualized endoscopically: shortness of length, thinness, narrowness, deformed borders and contours, dorsal buckling of tip (when the palate is drawn upward by negative nasopharyngeal pressure), poor conformational fit of the epiglottis to the soft palate, and flaccidity. Experience in evaluating endoscopic findings is helpful because the determination of abnormalities is subjective. Flaccidity may vary between endoscopic examinations, with the use of xylazine, and between rest and exercise on a high-speed treadmill.[7] Lateral radiographs of the throatlatch can be used to determine thyroepiglottic length. In one study, the average thyroepiglottic length in horses with dorsal displacement of the soft palate was approximately 2 cm shorter than the average length in normal horses.[6]

Diagnosis of intermittent dorsal displacement of the soft palate is based on the history, physical examination, evaluation of the horse while performing, and endoscopic examination. Unlike horses with persistent dorsal displacement of the soft palate, horses with intermittent dorsal displacement of the soft palate are usually asymptomatic at rest and the palate is in a normal position. Endoscopy is most useful when done while the horse is exercising on a treadmill. However, endoscopic examination at rest allows evaluation of the nasopharynx and larynx for other abnormalities that may predispose to intermittent dorsal displacement of the soft palate. The clinician can perform various procedures such as holding off the nostrils and injecting water into the pharynx to evaluate soft palate function. These tests have been described in detail.[2, 3] Ulceration of the caudal border of the soft palate suggests that intermittent dorsal displacement of the soft palate has been occurring during exercise.

Numerous methods of treatment exist for intermittent dorsal displacement of the soft palates. Conservative management should include a tongue-tie to prevent

or decrease retraction of the tongue, adjusting tack so the horse can work with the head and neck extended, improving fitness in poorly conditioned horses, and treating any underlying medical problems such as bronchitis. Medical therapy should be attempted before surgical intervention. Surgical treatments include myectomy of the sternothyrohyoid muscles, myectomy of the sternothyrohyoid and omohyoid muscles, sternothyroideus tenectomy, staphylectomy, epiglottic augmentation with polytetrafluoroethylene paste, and combinations of these procedures.

Sternothyrohyoideus myectomy is technically easy to perform, can be done on the standing horse, results in few complications, requires a short rest period before resumption of training, and is less expensive than the other procedures. Sternothyrohyoideus myectomy is the procedure of choice in horses without abnormalities of the epiglottis or soft palate. In two separate studies, 59% and 60% of racehorses undergoing this procedure raced successfully.[1, 7] However, success after sternothyrohyoideus myectomy in horses with epiglottic abnormalities is not as good. Some surgeons believe sternothyrohyoideus myectomy has little value for treating intermittent dorsal displacement of the soft palate in horses with hypoplasia or flaccidity of the epiglottis. Epiglottic augmentation with polytetrafluoroethylene paste has been performed for treatment of intermittent dorsal displacement of the soft palate in horses with epiglottic hypoplasia or flaccidity.[4, 8] The purpose of epiglottic augmentation is to increase the rigidity of the epiglottis, thus reducing the tendency for dorsal displacement of the soft palate. Augmentation is often combined with staphylectomy and sternothyrohyoideus myectomy. Augmentation, staphylectomy, and myectomy also may be selected for treatment of horses with intermittent dorsal displacement of the soft palate in the absence of epiglottic abnormalities or when conservative treatment or sternothyrohyoideus myectomy has failed.

Staphylectomy alone has been used successfully to treat intermittent dorsal displacement of the soft palate. Staphylectomy was successful in improving racing performance in 59% of Standardbred and Thoroughbred racehorses in one study.[1] Nearly one half of the horses in this group had epiglottic abnormalities.

Sternothyrohyoideus Myectomy

Anesthesia, Positioning, and Surgical Preparation

Surgery can be done with the horse sedated and standing. The head should be extended to a 45° angle with the neck to tense the sternothyrohyoideus muscles during surgery. Hair is removed on the ventral aspect of the neck from the mandible to the middle of the neck and laterally to the jugular furrows. Routine surgical preparation of the skin is done. Local anesthetic is injected along the ventral midline for 10 cm. The anesthetic is instilled at the junction of the proximal and middle thirds of the neck centered over the eighth to tenth tracheal rings. The subcutaneous tissues and strap muscles are infiltrated to the depth of the trachea. At the level of the eighth to tenth tracheal rings, the sternothyrohyoideus muscles are easily identified, isolated, and transected, and hemorrhage is usually not severe. The paired sternothyroideus muscles are separate from the sternohyoideus muscle, but they have not yet diverged laterally toward the thyroid cartilage (Fig. 30–1*A*). The omohyoideus muscles have not yet converged and blended with the sternohyoideus muscle. Also, large vascular branches to the muscles that occur at the level of the sixth tracheal ring can be avoided.[9]

A second surgical preparation should be performed after the local anesthetic has been instilled. The surgeon should wear sterile gloves and use autoclaved instruments. Drapes are not used. The surgeon must be cautious not to touch unprepared areas of skin. We do not routinely administer prophylactic antibiotics.

Surgery

A 6- to 8-cm-long incision is made through the anesthetized skin on the ventral midline of the neck. The sternothyrohyoideus muscles can be easily palpated at this level with the horse's head extended. The incision is continued with the scalpel through the subcutaneous tissue, cutaneous colli muscle, and the sternothyrohyoideus muscles to the trachea (see Fig. 30–1*A*). The sternohyoideus muscle is easily split with the knife blade on the midline. This separation establishes the thickness of the sternohyoideus muscle and makes identification and isolation of the muscles from the surrounding tissues less difficult. Dissection of the muscles is continued with scissors laterally along the trachea until the lateral edges of both sides of the sternothyrohyoideus muscles are reached. The ventral surface of the muscles are then separated from the cutaneous colli and sternomandibularis muscles with scissors and blunt finger dissection. Once undermined and separated from surrounding tissues, the combined sternothyrohyoideus muscles are elevated from the wound (Fig. 30–1*B*). A 5-cm length of the sternothyrohyoideus muscles is removed by cross-clamping the muscles with two Ochsner, Péan, or similar forceps. Mayo scissors are used to cut the muscle between the clamps to remove the 5-cm section. The forceps are released from the remaining ends of the sternothyrohyoideus muscles, which will retract, leaving dead space next to the trachea. Hemorrhage is usually minimal. Any small arterial bleeders can be clamped with hemostats. The cutaneous colli muscles are closed with a simple continuous suture pattern using size 2–0 polydioxanone[a] suture material. The same pattern and material are used to close the subcutaneous tissues. Skin is closed with simple interrupted or simple continuous sutures of nonabsorbable, noncapillary material.

Some surgeons favor a slightly different procedure for cutting the ventral neck muscles that retract the larynx.[9] This alternative procedure consists of sternothyrohyoideus myectomy and partial omohyoideus myectomy in the proximal third of the neck just caudal to the larynx. This procedure requires more dissection and is more apt to bleed and form seromas postoperatively. Surgery may be performed standing or after induction of general anesthesia.

[a]PDS II, Ethicon, Inc., Somerville, NJ.

Postoperative Management

Four or five sterile gauge surgical sponges are placed over the skin incision, and a snug bandage is wrapped around the neck. The bandage should be loose enough, however, to allow swallowing and venous drainage. We prefer to use adhesive, stretchable bandaging material. The bandage provides counterpressure to the wound to reduce edema, hematoma, and seroma formation and to provide protection. The bandage should be left on the neck for 5 days and changed only if wet, soiled, or displaced. Sutures should be removed in 7 to 10 days. Horses can be rested for 5 days and then returned to training. Complications are unusual.

Two-year-old horses with progressive increase in the frequency of intermittent dorsal displacement of the soft palate have a poor prognosis.[2] Sternothyrohyoideus myectomy is not useful for persistent dorsal displacement of the soft palate.

Figure 30–1.

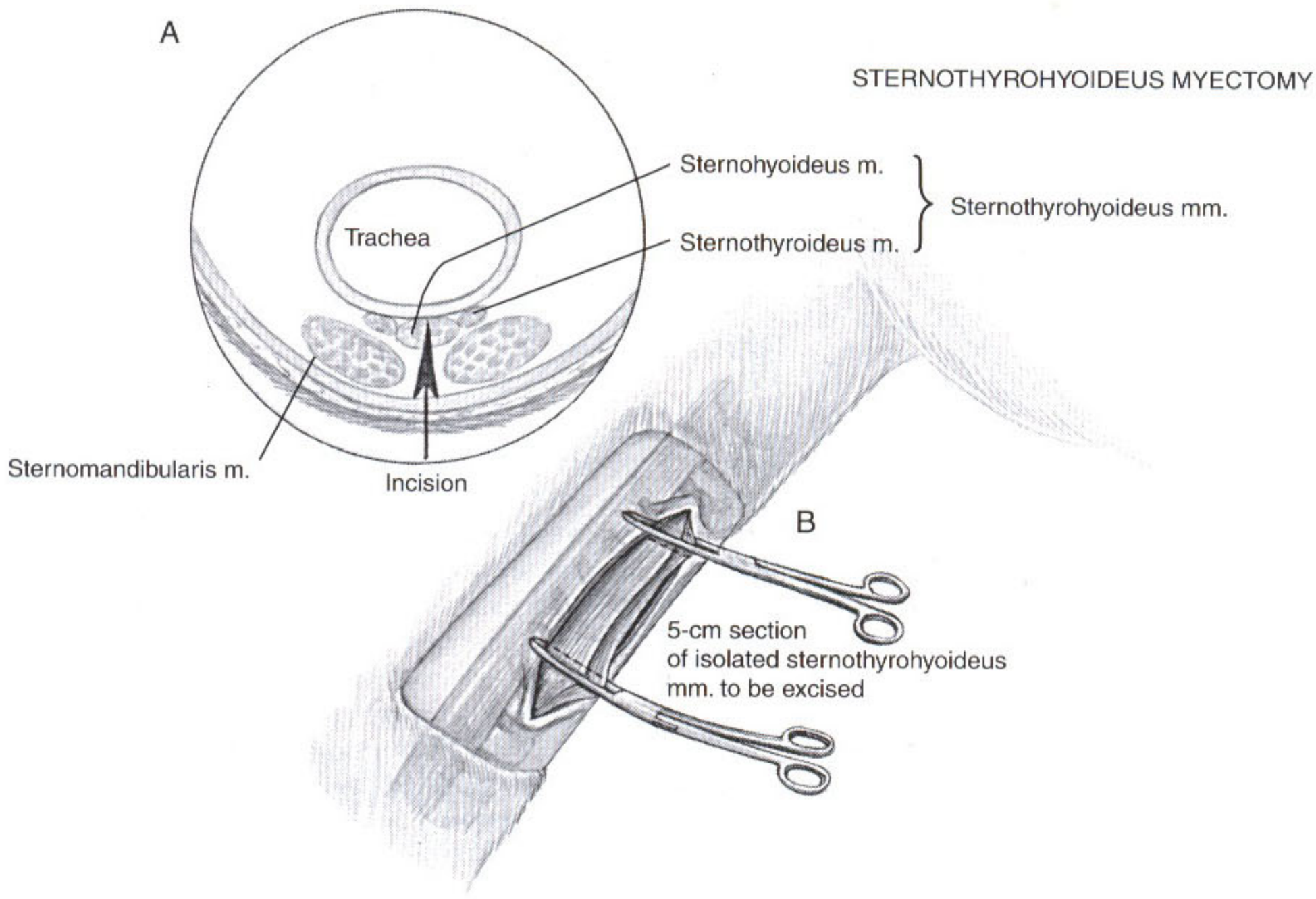


Illustration continued on page 161

Epiglottic Augmentation and Staphylectomy

Anesthesia, Position, and Surgical Preparation

Perioperative antibiotics are administered before surgery. After induction of general anesthesia, the horse is positioned in dorsal recumbency and prepared for routine laryngotomy. An 18- to 20-mm nasotracheal tube or a 20-mm endotracheal tube will allow more space in the larynx for manipulation and eversion of the epiglottis than a larger endotracheal tube. A nasotracheal tube does not have to be removed to grasp the soft palate for the staphylectomy.

Injection of the polytetrafluoroethylene[b] submucosally on the ventral surface of the epiglottis requires an Arnold-Bruening intracordal injection syringe.[c] This syringe is a high-pressure steel syringe with reusable needles that is designed for injection of viscous materials.

Surgery

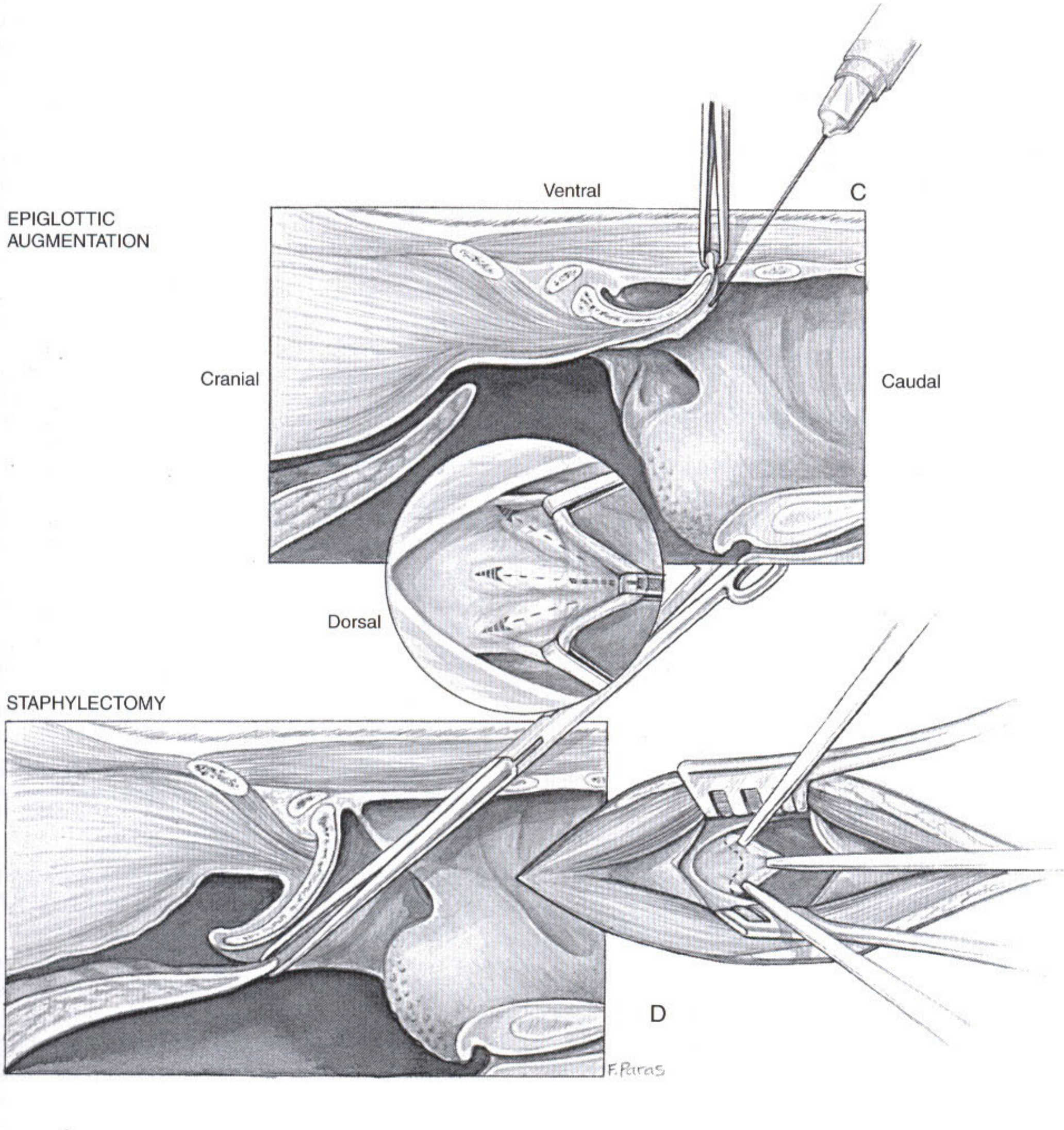
A standard laryngotomy incision is made between the cricoid and thyroid cartilages, and the lumen of the larynx is entered. A Hobday roaring retractor[d] or Gelpi retractor is positioned to keep the laryngotomy incision open. The epiglottis is retroverted into view by grasping the lateral aryepiglottic folds with Allis tissue forceps and pulling caudally until the dorsal surface of the epiglottis is visualized. The epiglottis is stabilized within the larynx by grasping the aryepiglottic fold on both sides on the midline and grasping adjacent to the tip of the epiglottis, with three Allis tissue forceps (Fig. 30–1*C*). The forceps should be placed in the stretched aryepiglottic fold approximately 1 cm from the cartilage border of the epiglottis. Large-diameter endotracheal tubes may need to be removed during retroversion of the epiglottis and should be replaced immediately after the epiglottis is retroverted and stabilized with the Allis forceps. The triangular shape of the epiglottis can be seen and felt within the aryepiglottic folds. By elevating the forceps adjacent to the tip of the epiglottis, the ventral epiglottic surface is exposed. Three to 5 ml of polytetrafluoroethylene paste is injected submucosally on the ventral surface of the epiglottis using the Arnold-Bruening syringe and a 5- to 6-cm long needle (see Fig. 30–1*C*). The needle should penetrate the mucosa on midline about 5 mm caudal to the tip of the epiglottic cartilage and should be advanced submucosally for 5 cm. An index finger placed ventral to the epiglottis can confirm proper position of the needle. As the needle is withdrawn, one third to one half of the total volume of paste is injected along the ventral midline of the epiglottis. An additional line of paste is injected on each side of midline through the same needle entrance portal to create a fan-shaped pattern. More paste is deposited toward the tip of the epiglottis with this technique. The paste can be distributed submucosally by gentle massage. The exact amount of polytetrafluoroethylene paste injected is based on subjective assessment of the size, shape, and flaccidity of the epiglottis.

The epiglottis is released and allowed to return to a normal position. An oral endotracheal tube will need to be removed from the larynx and oropharynx to allow access to the soft palate. The tube does not have to be removed completely from the oropharynx because it will be reinserted once the staphylectomy is completed. The soft palate may be ventral to the epiglottis in horses with nasotracheal intubation. Depressing the epiglottis ventrally with an index finger usually displaces the soft palate dorsal to the epiglottis, where it can be visualized. The free margin of the soft palate is grasped with a long-handled Allis tissue forceps or sponge forceps on midline and retracted caudally (Fig. 30–1*D*). The forceps should grasp 5 to 8 mm of tissue. A second Allis tissue forceps is placed 5 to 8 mm lateral to the central Allis forceps and the palate stretched away from the second Allis forceps to tense the edge of the palate. The staphylectomy is begun by using long scissors to initiate a cut just lateral to the second forceps that tapers toward midline. The incision becomes wider up to the edge of the midline forceps. The lateral Allis forceps is removed, and the midline forceps is used to put traction on the palate toward the side already cut. The staphylectomy is completed by continuing the incision to the opposite free border of the palate. A crescent-shaped piece of soft palate 3 to 4 cm long and up to 1 cm wide when stretched maximally is removed. The cut edge of the palate and the laryngotomy are left open to heal by second intention.

A sternothyrohyoideus myectomy is often performed at the same time. This procedure should be

[b]Polytef paste, Mentor O & O, Norwell, MA.
[c]Arnold-Bruening injection set, Mentor O & O, Norwell, MA.
[d]Hobday roaring retractor, Jorgensen Laboratories, Inc., Loveland, CO.

Figure 30–1. *Continued*



done before epiglottic augmentation and staphylectomy, which are contaminated surgeries; alternatively, the surgeon can change gloves, redrape, and use different instruments if the myectomy is performed last.

Postoperative Management

Phenylbutazone and postoperative antibiotics are recommended for 5 days to help control the significant postoperative reaction to the paste and reduce chances of infection. The laryngotomy incision should be cleaned and the surrounding skin coated with petroleum jelly until drainage ceases. Horses should be rested in a stall for 30 days and hand exercised once or twice daily. Training is generally resumed in 4 to 6 weeks.

The polytetrafluoroethylene paste creates fibroblastic proliferation and a well-circumscribed foreign body granulomatous reaction.[4, 5] This reaction causes thickening of the epiglottis and increases rigidity.[5] Immediately after surgery, marked epiglottic edema and inflammation may develop, which may require up to 2 weeks to subside.[4, 5] Ulceration of the mucosa ventral to the epiglottis and persistent dorsal displacement of the soft palate also have been noted.

In one study, 17 of 28 (61%) racehorses with intermittent dorsal displacement of the soft palate associated with epiglottic hypoplasia or flaccidity won at least one race after augmentation and staphylectomy.[4] Most horses in the study were Thoroughbreds. Seven other horses improved. In another study, 40 Thoroughbred and 19 Standardbred racehorses underwent augmentation, staphylectomy, and myectomy. The racing performance of 73% of the Thoroughbreds and 53% of the Standardbreds improved.[8]

Other Surgical Procedures

The combination of sternothyroideus tenectomy and staphylectomy has become common in Standardbred horses in the eastern United States.[10] The larynx is approached by a standard laryngotomy, but before the cricothyroid ligament is incised to enter the larynx, dissection is continued to the ventrolateral sides of the larynx to identify, isolate, and transect the tendons of the insertion of the sternothyroideus muscles as they attach to the caudal aspect of each side of the thyroid cartilage. The tendon can be isolated with a spay hook using minimal dissection and can be transected with scissors. Care should be taken not to sever a small vein that often lies adjacent to the tendon. Staphylectomy is performed, removing approximately a 9-mm-wide section of tensed palate. Jogging of these Standardbred horses resumes the day after surgery, and full training starts 10 to 14 days later.

The causes of intermittent dorsal displacement of the soft palate are nearly as varied as the number of treatments. Current and ongoing research may help to define the problem more clearly and determine which surgical procedure or procedures are best.

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chapter 31

Treatment of Epiglottic Entrapment

Epiglottic entrapment occurs when the aryepiglottic folds and subepiglottic mucous membrane envelop the epiglottis. The subepiglottic mucosa is normally redundant and loose, allowing for epiglottic movement during deglutition. Epiglottic abnormalities, particularly shortening or hypoplasia, and inflammation and swelling of the subepiglottic tissues may predispose to epiglottic entrapment.[1] Horses with a normal epiglottis also may acquire epiglottic entrapment. Some horses with epiglottic entrapment show no clinical signs.[2] Other horses will cough occasionally.[3] Most affected horses exhibit exercise intolerance and respiratory noise on exertion.[3, 4] However, epiglottic entrapment can obstruct air flow and cause exercise intolerance without producing a respiratory noise.[3] Epiglottic entrapment can be diagnosed by endoscopic evaluation of the larynx. Entrapment must be differentiated from dorsal displacement of the soft palate.[3] Although the outline of the epiglottis is visible, the entrapped epiglottis will be covered to various degrees with a membrane that obscures the serrated edge and the epiglottic vasculature. Ulceration of the entrapping membrane over the apex of the epiglottis may occur. Epiglottic entrapment may be intermittent, with entrapment occurring during exercise.[1] Endoscopic observation of the entrapment may occur right after exercise or while observing the horse on a high-speed treadmill. Horses that entrap during exercise and, subsequently, unentrap at rest may exhibit occasional entrapment during swallowing.

Epiglottic entrapment of short duration may resolve if the horse is rested for 7 to 10 days and given anti-inflammatory drugs. However, entrapment may recur when training resumes.[1] The entrapping mucous membrane can be resected via a ventral laryngotomy incision. The membrane has been excised side to side across the epiglottis after eversion of the epiglottis into the laryngotomy incision. This technique has been associated with an unacceptable level of postoperative dorsal displacement of the soft palate and a low success rate.[4, 5] Many surgeons favor correcting epiglottic entrapment by dividing the entrapping membrane on the midline over the dorsal aspect of the epiglottis, allowing the aryepiglottic folds and subepiglottic mucosa to slip laterally off the epiglottis. Midline division of the entrapping membrane may be performed with long, hooked, cutting instruments placed through the mouth or nose,[1, 5, 6] with endoscopic electrocautery,[4] or with endoscopically guided laser surgery.[7] The latter two methods require specialized equipment and stringent safety precautions. Midline division of the epiglottic entrapment with a long cutting instrument is technically easy, and horses can be returned to training in as few as 10 days. The procedure can be done on the standing sedated horse through the nasal passage using endoscopic visualization.[6] This method is not without risk to the surgeon when operating on fractious horses, and structures other than the entrapping membrane may be lacerated if the horse struggles or swallows. The oral approach requires a short-acting general anesthetic, which reduces the risk to the surgeon and to the horse by providing better control for cutting the membrane.[1] The oral technique is performed by palpation or with endoscopic visualization.[5] Surgeons with large hands working on small horses may have difficulty performing surgery by palpation.

Anesthesia, Positioning, and Surgical Preparation

The mouth of the horse should be thoroughly flushed to remove food residue before inducing anesthesia. The horse is anesthetized with a short-acting intravenous drug combination. We prefer a xylazine,[a] ketamine,[b] and guaifenesin[c] combination with a sufficient depth of anesthesia to reduce swallowing during surgery. The horse is positioned in left lateral recumbency for right-handed surgeons and the opposite side for left-handed surgeons. A large dental speculum[d] is secured in the mouth and opened maximally. A Bayer's wedge or a Rusher spool is less convenient for the

[a]Rompun, Miles Inc., Shawnee Mission, KS.
[b]Ketaset, Fort Dodge Laboratories, Inc., Fort Dodge, IA.
[c]Guailaxin, Fort Dodge Laboratories, Inc., Fort Dodge, IA.
[d]Mouth speculum, Western Instrument Co., Denver, CO.

surgery because they occupy space in the mouth. Long curved rods with a hook and sharp cutting edge at one end can be purchased commercially[e, f] or constructed of 30-inch-long rigid stainless steel welding rod 1/8 inch in diameter (Fig. 31–1). Commercial hook knives have shorter, more open hooks, which in our opinion are less desirable than longer, sharper hooks in custom-made instruments. To construct a cutting instrument, the rod is gently curved and a sharp bend is made at one end so 1 inch of rod bends backward. The end of the rod is sharpened to a point, and the inside of the hook is filed to make a cutting edge. The hook of the cutting instrument should be longer than the length of the entrapment. A short hook engages only the caudal margin of the mucosa, allowing most of the entrapment membrane to disengage from the epiglottis before it is cut.

Surgery

The hooked knife is carried in the hand back to the oral pharynx, and the entrapped epiglottis is palpated with the index finger. The entrapping membrane can be palpated to determine whether it is adhered to the epiglottis. The aryepiglottic and subepiglottic tissue must entrap the epiglottis to enable the hooked knife to engage the fold. If the entrapping membrane slips off the epiglottis, it can be replaced by pushing down on the epiglottis with the index finger and using the thumb to pull the subepiglottic membrane back over the tip of the epiglottis (Fig. 31–2*A*). The hooked knife is slipped over the caudal margin of the entrapping fold, and the hook is advanced rostrally between the fold and the epiglottis until it engages the membrane (Fig. 31–2*B*). The hook should be passed directly on midline. The sharp point of the hook is advanced rostrally until it perforates the rostral aspect of the entrapping fold (Fig. 31–2*C*). The surgeon should engage as much of the entrapping membrane as possible to reduce chances of postoperative recurrence. The surgeon can push the entrapping fold dorsally and caudally over the hook as the blade is withdrawn to increase the amount of fold that is divided. Once the proper position of the hook and cutting blade are determined by palpation, the knife is drawn rostrally to divide the entrapping membrane. The epiglottis is palpated to determine that it is free of entrapping membrane.

Alternatively, midline division can be done by visualizing the larynx with an endoscope passed through a Frick speculum[g] or other tube speculum. The knife is passed alongside the speculum to the epiglottis, and midline division is performed.

Postoperative Management

Horses should be rested for a minimum of 7 days. Nonsteroidal anti-inflammatory drugs can be administered to control pain and swelling. Horses can be returned to training 10 days after uncomplicated recovery

[e]Equine epiglottic entrapment knife, Sontec Instruments, Englewood, CO.

[f]Epiglottic entrapment knife, Kimzey, Inc., Woodland, CA.

[g]Frick's standard oral speculum, Jorgensen Laboratories, Inc., Loveland, CO.

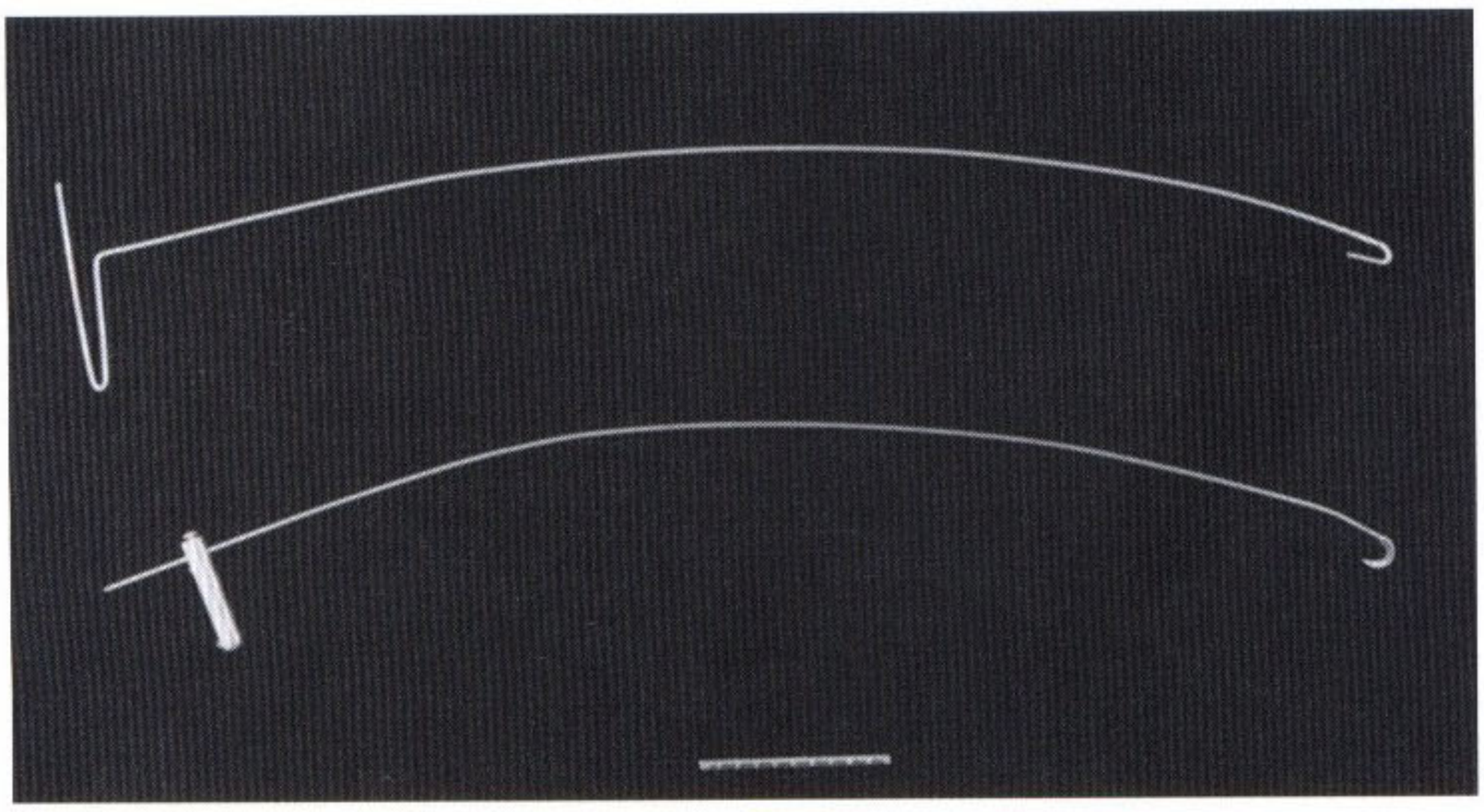
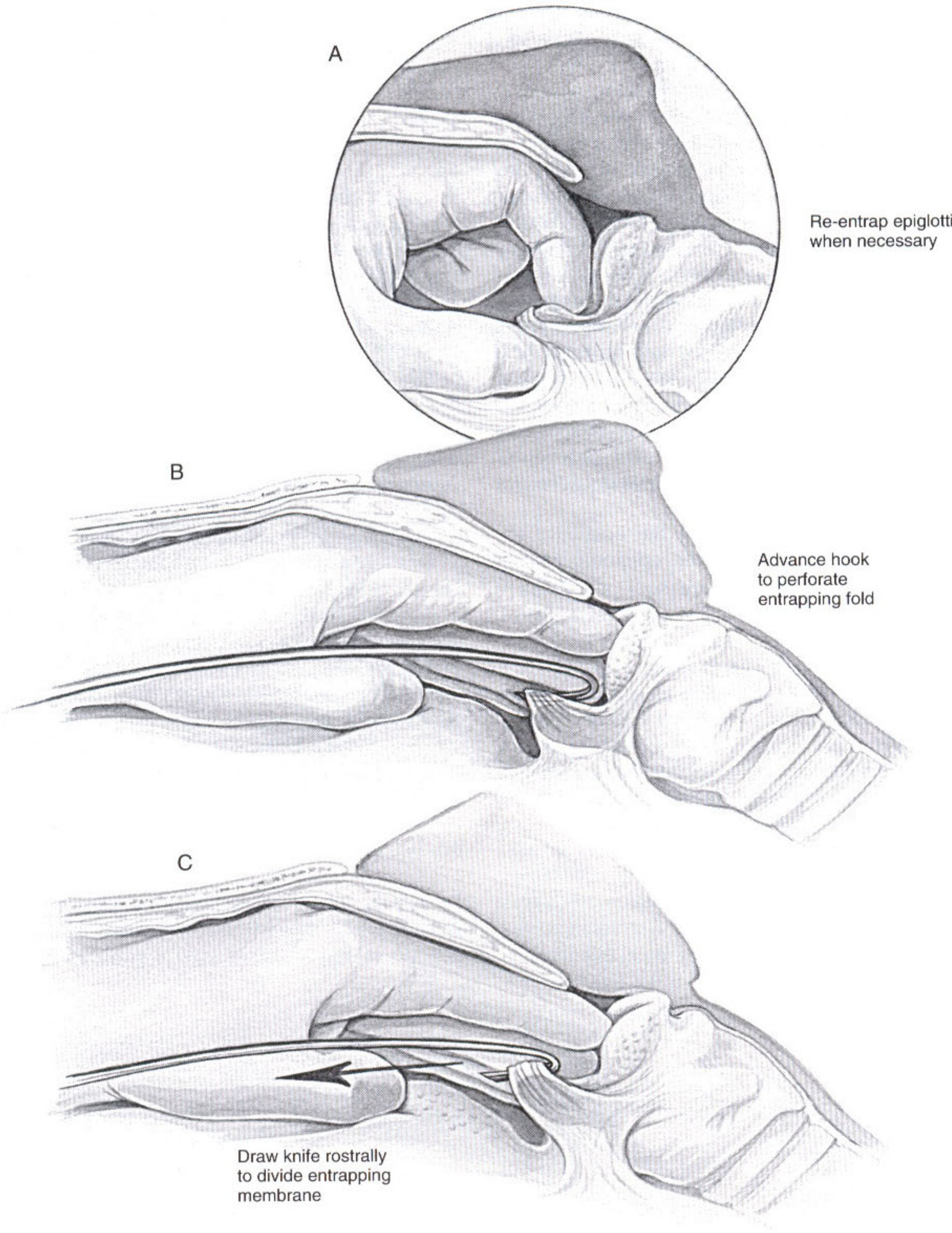


Figure 31–1.

Suitable long rods with hook knives (epiglottic hooks) that are used to divide the membrane entrapping the epiglottis.

Figure 31–2.


A
Re-entrap epiglottis when necessary
B
Advance hook to perforate entrapping fold
C
Draw knife rostrally to divide entrapping membrane

from surgery. Swelling of the cut edges of the entrapping membrane occurs to various degrees, and it is not uncommon for swelling to cause the cut edges of the aryepiglottic fold to protrude above the lateral edges of the epiglottis. These swollen edges usually retract to a normal position as swelling subsides.

Re-entrapment of the epiglottis after surgery is possible and occurs more often when the entire entrapping membrane is not divided. Re-entrapment may resolve with time, but we prefer to hook the fold and pull it off the epiglottis using endoscopic visualization in the standing horse. Laryngotomy and resection of the entire entrapping membrane may be done if re-entrapment is chronic and persistent.

Dorsal displacement of the soft palate is not uncommon after surgery for entrapment of the epiglottis; as many as 20% of horses experience this complication.[4] Dorsal displacement occurs more frequently in horses undergoing laryngotomy and resection of the aryepiglottic folds.[4,5] When dorsal displacement persists beyond 2 weeks after entrapment surgery, procedures to attempt correction of dorsal displacement of the soft palate should be considered.

The prognosis for eliminating the epiglottic entrapment is very good. Horses with epiglottic entrapment uncomplicated by ulcers of the entrapping membrane, preoperative dorsal displacement of the soft palate, previous surgery, or epiglottic hypoplasia have a fair prognosis (approximately 80% success) for athletic use.[5–7] The results for athletic use are not good if preexisting complications are present.

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chapter 32

Excision of Subepiglottic Cysts

Subepiglottic cysts are an uncommon cause of upper airway obstruction and dysphagia in horses. They have been reported most frequently in Standardbred and Thoroughbred racehorses but occur in other breeds.[1] Most cysts are believed to be embryologic remnants of the thyroglossal duct, but inflammation of the subepiglottic region with blockage of mucus-secreting glands may be responsible for formation of some cysts. In young foals, subepiglottic cysts cause dysphagia, aspiration pneumonia, and respiratory airway obstruction.[2] The foals often cough and have bilateral mucopurulent nasal discharge. In young racehorses, subepiglottic cysts most often cause exercise-induced inspiratory and expiratory noise and exercise intolerance.

The diagnosis of subepiglottic cysts is made by endoscopic examination. In most horses, the cyst is visualized as a 1- to 5-cm-diameter smooth, round mass beneath the epiglottis. However, some cysts are rostral to the caudal margin of the soft palate and hidden from endoscopic view. Prolonged endoscopic observation and induced swallowing usually allow temporary visualization. Lateral plain radiography, contrast radiography of the oral pharynx, and oral digital palpation of the epiglottis and subepiglottic area will help confirm the diagnosis and determine the size and shape of the subepiglottic cyst.

Excision of the subepiglottic cyst is the method of treatment. Cysts may be excised through a laryngotomy incision, per os using a wire snare, or per os using a neodymium:yttrium aluminum garnet (Nd:YAG) laser.[3] The method of removal depends mostly on the surgeon's preference. The wire snare method will be difficult for surgeons with large hands working in horses with small mouths. With all three methods, the surgeon should ensure removal of the secretory lining of the cyst and should preserve as much of the ventral pharyngeal mucosa as possible. Failure to remove the lining will result in re-formation of the cyst. Removal of excessive mucosa may result in scar tissue adhesions beneath the epiglottis with postoperative intermittent or persistent dorsal displacement of the soft palate.

Anesthesia, Positioning, and Surgical Preparation

Excision of subepiglottic cysts via laryngotomy is technically simple and gives good exposure of the cyst. Surgical time is generally 15 to 25 minutes for experienced surgeons. Preoperatively, phenylbutazone, 4.4 mg/kg, is administered intravenously. Perioperative and postoperative antibiotic administration is at the surgeon's discretion. We generally do not administer antibiotics. Either inhalation gas anesthesia or intravenous anesthesia is satisfactory. The horse is positioned in dorsal recumbency with the head and neck extended for laryngotomy. Routine surgical preparation of the surgical site is performed.

Surgical Procedure

A routine laryngotomy is performed to gain access to the lumen of the larynx. The epiglottis is everted into the larynx by grasping the aryepiglottic folds with an Allis tissue forceps and applying traction. The epiglottic tip is pulled backward and upward to expose the cyst on the ventral surface of the epiglottis (Fig. 32–1*A*). When one is used it may be necessary to remove an endotracheal tube temporarily during eversion of the epiglottis and cyst. The tube is replaced after eversion and can aid in keeping the epiglottis and cyst from retracting back into the pharynx. The thyroid cartilage can be split with heavy scissors if additional exposure is needed. The mucosa over the cyst is incised in a longitudinal direction (Fig. 32–1*B*). The cyst is carefully dissected free of surrounding connective tissue with a combination of blunt and sharp dissection using Metzenbaum scissors. The surgeon should avoid puncturing or rupturing the cyst because the intact cyst is easier to excise from the surrounding tissues. Inadvertent punctures can be closed with a curved hemostat to prevent loss of the mucous contents and collapse of the cyst. The cyst is freed around its surface and excised by cutting through the stalk at the base of the epiglottis (Fig. 32–1*C*). Ruptured cysts should be carefully examined to ensure that all lining epithelium has been removed. If complete excision of all secretory epithelium is not possible or is in question, the area ventral to the epiglottis can be carefully swabbed with 2% aqueous iodine in an attempt to destroy remaining cyst lining. The mucosal defect remaining after cyst excision need not be sutured; however, some surgeons prefer to appose the mucosa with three or four buried simple interrupted absorbable sutures. The laryngotomy incision is left open.

Postoperative Management

The laryngotomy incision should be cleaned several times a day until closed, and petroleum jelly can be applied to the skin surrounding the incision for protection from discharges. These horses should be rested for 4 weeks. Training can be resumed after endoscopic examination ensures that healing of the subepiglottic area is satisfactory. Foals with concomitant aspiration pneumonia should be treated with antibiotics selected on the basis of culture and sensitivity testing of tracheal aspirates. Complications from surgery are infrequent but can include laryngeal edema, swelling of subepiglottic mucosa, pain, incisional infection, recurrence of the cyst if the entire secretory epithelial lining has not been removed, and fibrosis of the epiglottis with intermittent or persistent dorsal displacement of the soft palate. The prognosis for athletic use is good. Foals can make full recovery if the aspiration pneumonia responds to therapy.

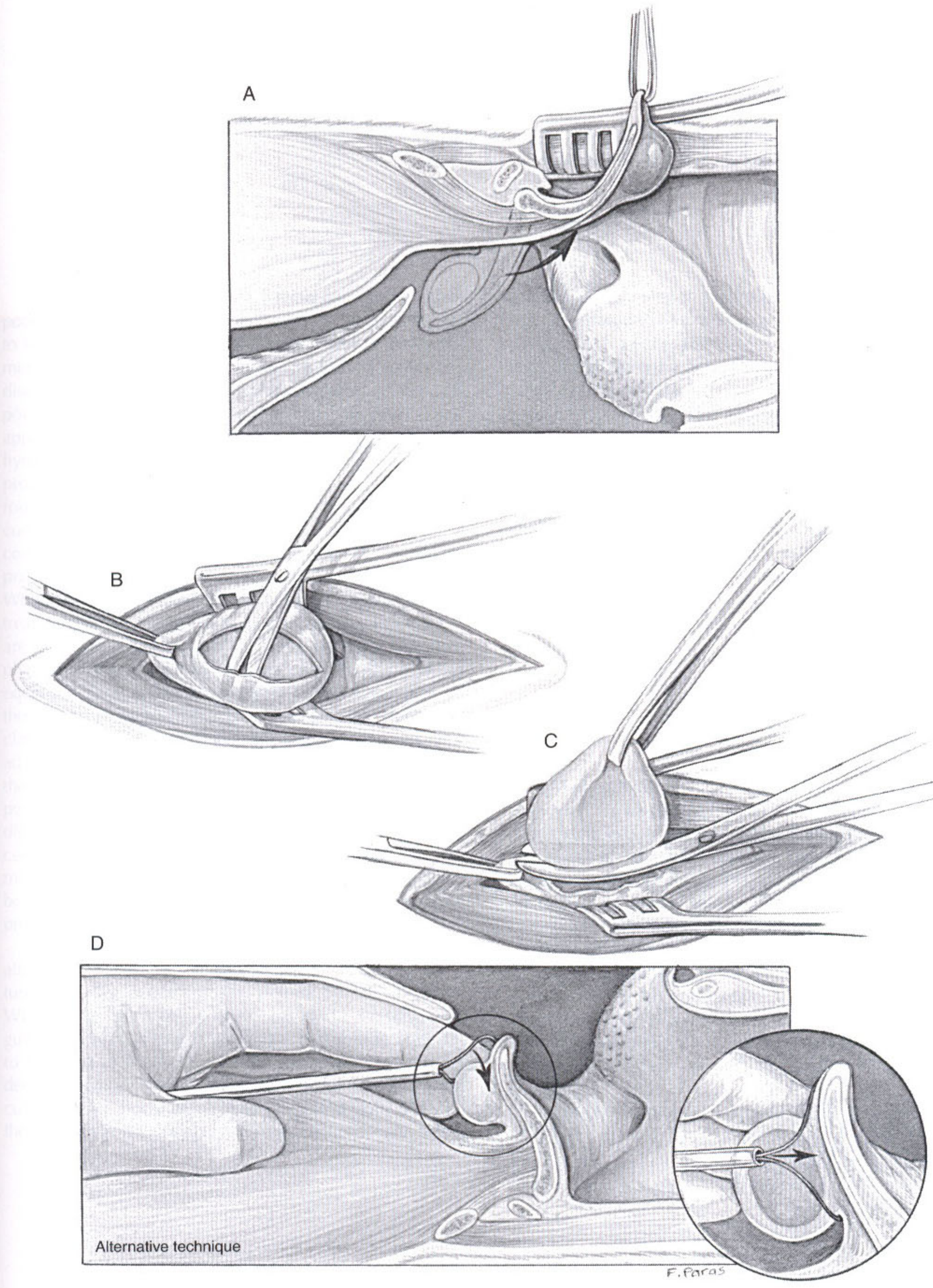
Alternative Surgical Procedure

Some surgeons prefer to remove subepiglottic cysts through the mouth using a wire snare.[3] The snare is constructed using a 40-cm-long steel tube or a mare urinary catheter through which obstetric wire is threaded to leave a loop snare at one end. The horse is anesthetized with intravenous anesthesia and positioned in lateral recumbency with the head and neck extended. For right-handed surgeons, the horse is placed in left lateral recumbency. A mouth speculum is positioned so that the jaws are opened maximally. The surgeon passes the hand and snare through the mouth and positions the snare around the cyst (Fig. 32–1*D*). Only the cyst and as little mucosa as possible are encircled by the snare. An assistant can then grasp the ends of the wire snare with needle holders or pliers and pull the wire ends with a sawing motion to excise the cyst. The surgeon should continually monitor the snare position during the excision to ensure that the cyst is completely removed and that no other structures are damaged. In the absence of a laryngotomy, horses can be returned to training in 1 to 2 weeks if endoscopic examination reveals satisfactory healing of the mucosal defect.

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Figure 32–1.



chapter 33

Modified Whitehouse Approach to the Guttural Pouch

The equine surgeon may need to enter the guttural pouch to drain pus, remove chondroids, or gain access to the medial septum and pharyngeal orifice for treatment of guttural pouch tympany. Standard textbooks discuss the pathophysiology and diagnosis of guttural pouch diseases and the indications for surgery.[1–3] Four approaches to the guttural pouch are commonly used: hyovertebrotomy, Viborg's triangle, the Whitehouse approach, and the modified Whitehouse approach. All four approaches may be followed by postoperative complications because several cranial nerves lie adjacent to the pouch and may be damaged by the disease process or by surgery. Some surgeons avoid the Whitehouse and modified Whitehouse approaches for treatment of empyema, believing that these approaches are more likely than others to cause postoperative dysphagia.[4] Other surgeons believe complications occur equally among approaches and note the advantages of the Whitehouse techniques.[2] Retrospective studies to clarify this controversy have not been performed. The advantages of the modified Whitehouse approach to the guttural pouch include excellent ventral drainage of pus, access to the roof of the guttural pouch, access for digital exploration of the lateral compartment, and access to the medial septum and pharyngeal orifice.[1, 2] In most horses, the modified Whitehouse approach gives better access to the pouch than the Whitehouse approach.

Distention of the guttural pouch with air or fluid alters the anatomy of the pouch and surrounding structures, making access to the pouch by the modified Whitehouse approach easier. Distention stretches the guttural pouch so that the mucous membrane is closer to the skin at the surgical site, reducing the need for deep dissection. The nondistended pouch may be difficult to locate because of deep dissection and because the mucosa collapses away from the skin incision when the horse is in dorsal recumbency. The surgeon can facilitate identification and exposure of the pouch by using an endoscope for transillumination or putting a rigid catheter into the affected pouch via the pharyngeal orifice and then palpating the end of the catheter. The stylohyoid bone can also be used for a surgical landmark.

Most surgical approaches to the guttural pouch are performed on anesthetized horses. However, when the guttural pouch is greatly distended with pus, ventral drainage can be established with a Viborg's triangle or modified Whitehouse approach in the standing horse. There is greater risk of damaging nerves and other vital structures. Also, good visualization of the guttural pouch is precluded when surgery is performed in the standing horse.

Anesthesia, Positioning, and Surgical Preparation

After induction of general anesthesia, the horse is positioned in dorsal recumbency with the head and neck extended. A routine surgical preparation is performed at the throatlatch, and the surgical site is draped. Surgical suction should be available when treating horses with empyema and can be useful for other problems as well. A malleable, Sauerbruch, large Senn, or other flat-bladed retractor will aid exposure and visualization. Rake retractors are traumatic and inappropriate for this surgery. An endoscope or rigid Chambers mare catheter[a] should be available to use as an aid in identifying nondistended pouches and the location of the pharyngeal orifice.

[a]Chambers mare catheter, Jorgensen Laboratories, Inc., Loveland, CO.

Surgery

A 10- to 15-cm-long incision through the skin and subcutaneous tissues is made parallel with and just ventral to the linguofacial vein starting from its junction with the jugular vein and incising cranially (Fig. 33–1*A*). The sternohyoideus and omohyoideus muscles are separated from the linguofacial vein, and a plane of dissection is established in the loose fascia lateral to the larynx (Fig. 33–1*B*). This is the same dissection that is done for the initial stages of laryngoplasty. The mucous membrane of the medial compartment of a very distended guttural pouch is often encountered lateral to the larynx, in a superficial location, and is readily located. The membrane is very thin in foals with guttural pouch tympany uncomplicated by secondary infection. The nerves around the pouch should be preserved. In horses with empyema or guttural pouch mycosis, the mucous membrane lining is thickened and inflamed. The nerves are more difficult to observe. The plane of dissection must be carried around the lateral aspect of the larynx and dorsally to reach nondistended pouches. Blunt dissection should be used to avoid severing nerves or lacerating vessels. The stylohyoid bone is used as a landmark. The passage of an endoscope or rigid Chambers catheter into the nondistended pouch will also aid in the identification of the pouch.

The guttural pouch is opened longitudinally by grasping the lining with an Allis tissue forceps or thumb forceps and incising it with scissors (Fig. 33–1*C*). Tympanitic pouches will collapse immediately, and the edges should be secured with a forceps until a blade retractor can be inserted into the pouch to gently hold it open. Pus and chondroids are removed from infected pouches, and the pouch is lavaged with sterile saline. The median septum can be fenestrated and the pharyngeal orifice enlarged in foals with guttural pouch tympany (see Chapter 34). We leave the guttural pouch incisions open to heal by second intention. However, guttural pouch incisions can be sutured closed if no infection is present and postoperative drainage is not necessary.

Postoperative Management

The skin around open incisions should be cleaned daily and protected by petroleum jelly, zinc oxide ointment, or other suitable protectant. The horse should be rested until the open wound heals; this usually occurs in 14 to 21 days. The horse should be fed on the ground to promote guttural pouch drainage and reduce the chances of aspiration if dysphagia develops. Dysphagia is uncommon but may result in fatal aspiration pneumonia. Horses with empyema should be treated with postoperative flushing of the pouches and other appropriate treatment such as systemic antibiotics. Solutions used for flushing should be nonirritating. Guttural pouches have been flushed using a 10% (volume per volume) solution of povidone-iodine in saline or water. This solution may not be effective in the presence of pus and is irritating to the pouch.[5] We use balanced polyionic solutions without antiseptics. The most important aspect of flushing is the mechanical lavage that hastens removal of pus and inflammatory mediators. Other complications following the modified Whitehouse approach are related to the primary disease.

Viborg's Triangle Approach

Viborg's triangle approach is an alternative to the modified Whitehouse approach. Viborg's triangle is bordered by the ramus of the mandible rostrally, the linguofacial vein ventrally, and the tendon of the sternomandibularis muscle dorsally. The approach to the distended guttural pouch through Viborg's triangle is relatively easy because the pouch distends to a position near the skin. To enter the pouch, a 4-cm incision just dorsal and parallel to the linguofacial vein is made through the skin starting just caudal to the mandible. The subcutaneous tissue is incised. The parotid gland may need to be reflected dorsally. The guttural pouch membrane is identified and grasped with a forceps. Scissors are bluntly stabbed into the pouch, and the incision is opened to allow access to the pouch. This surgery can be performed on the standing sedated horse after instillation of local anesthetic when the pouch is markedly distended. Nondistended pouches are difficult to locate and open, and such horses should be anesthetized for surgery.

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chapter 34

Median Septum Fenestration and Pharyngeal Orifice Enlargement for Guttural Pouch Tympany

Guttural pouch tympany in foals is characterized by distention of the guttural pouch with air. Nonpainful swelling of the parotid region of the neck is typical. Affected foals may also exhibit respiratory noise, dyspnea, dysphagia, and aspiration pneumonia. Secondary infection of the pouches may occur. Clinical signs are usually noted within several weeks or months of birth, and the disease is more common in fillies.[1] Guttural pouch tympany is believed to be caused by a congenital defect in the pharyngeal orifice, which causes it to function as a one-way valve, allowing air to enter the pouch but not escape.[2] Guttural pouch tympany is most often unilateral, but bilateral disease may occur. Marked distention of one pouch will cause the swelling to be apparent on both sides of the throatlatch. The swelling may be nearly symmetric, making a determination of unilateral or bilateral guttural pouch involvement difficult. A Chambers catheter[a] or endoscope passed into the affected guttural pouch will cause immediate deflation and collapse of the pouch. Catheterization of one pouch, with the resultant deflation of the swelling on both sides of the neck, confirms a unilateral condition and indicates which pouch is affected.

Foals with guttural pouch tympany require surgery. Two procedures have been described: fenestration of the median septum between the guttural pouches and enlargement of the pharyngeal orifice of the affected guttural pouch.[1–4] Either procedure alone may be effective for treatment of unilateral guttural pouch tympany.[1] Median septum resection creates a communication between pouches, which allows air in the abnormal pouch to egress through the pharyngeal orifice of the normal pouch. The fenestration should be liberal, creating a large stoma, which will be unlikely to close during the healing process. Enlargement of the pharyngeal orifice, by resecting the medial lamina of the pharyngeal orifice and trimming mucosa from the plica salpingopharyngeus, allows air to egress from the affected pouch. This technique alone may result in scarring and stricture of the pharyngeal orifice and recurrence of tympany.[5] We prefer the combination of procedures for treatment of unilateral guttural pouch tympany. Both procedures must be performed for treatment of bilateral guttural pouch tympany.[1]

For foals with unilateral tympany, surgery should be performed in the diseased pouch to avoid damage to the normal pharyngeal orifice in the unaffected pouch. The septum is fenestrated, and the pharyngeal orifice is enlarged. Air for both pouches can then egress through the normal pharyngeal orifice. Either the modified Whitehouse approach or Viborg's triangle approach to the affected guttural pouch is used for fenestration of the median septum and enlargement of the pharyngeal orifice. In the distended tympanitic pouch, there is little difference between approaches. The affected pouch extends laterally and ventrally to the larynx and distends around both sides of the linguofacial vein. The pouch is usually located immediately under the subcutaneous tissues. The modified Whitehouse approach may provide slightly better access and visualization of the plica salpingopharyngeus and pharyngeal orifice and is the approach we most often use.

[a]Chamber's equine catheter, Jorgensen Laboratories, Inc., Loveland, CO.

Anesthesia, Positioning, and Surgical Preparation

The foal should be anesthetized and positioned in dorsal recumbency with the head and neck extended. All foals should be intubated, even when intravenous anesthesia is used. The head may be turned slightly away from the side of the guttural pouch to be incised. A Chambers equine catheter is inserted through the nostril into the opposite guttural pouch from the pouch being approached. Alternatively, an endoscope can be inserted into the opposite pouch, providing transillumination of the median septum. A catheter should not be inserted into the tympanitic pouch before surgery because the pouch will collapse, making the landmarks for the surgical approach less obvious. Routine surgical preparation of the skin and surgical draping are done. Perioperative antibiotics are used routinely.

Suction should be available when pus is present in the guttural pouch. A flat blade or malleable retractor will aid visualization of the pharyngeal orifice in the interior of the pouch. A long Allis tissue forceps or thumb forceps (9 inches or longer), long Metzenbaum scissors, and a small, long-handled, sharp-pronged retractor[b] are used for enlarging the pharyngeal orifice.

[b]Volkman sharp prong retractor, Sontec Instruments, Englewood, CO.

Surgery

The distended guttural pouch is opened with a modified Whitehouse approach as described in Chapter 33 (Fig. 34–1*A*). The membrane of the tympanitic pouch will be easily identified and opened. Nerves and vessels overlying the pouch should be preserved. The edges of the pouch can be secured with Allis tissue forceps, and a blade retractor can be used to improve visualization. An unscrubbed assistant should grasp the Chambers catheter at the nose and push the end of the catheter that is in the opposite guttural pouch against the median septum. The catheter and septum will be easily palpated and visualized (Fig. 34–1*B*). The septum is grasped with a thumb forceps, and a large fenestration is made with Metzenbaum scissors (Fig. 34–1*C*). Hemorrhage is usually minimal. The fenestration should be at least 2 cm in diameter to reduce the possibility of contraction and closure of the fistula as the cut edges heal.

Figure 34–1.

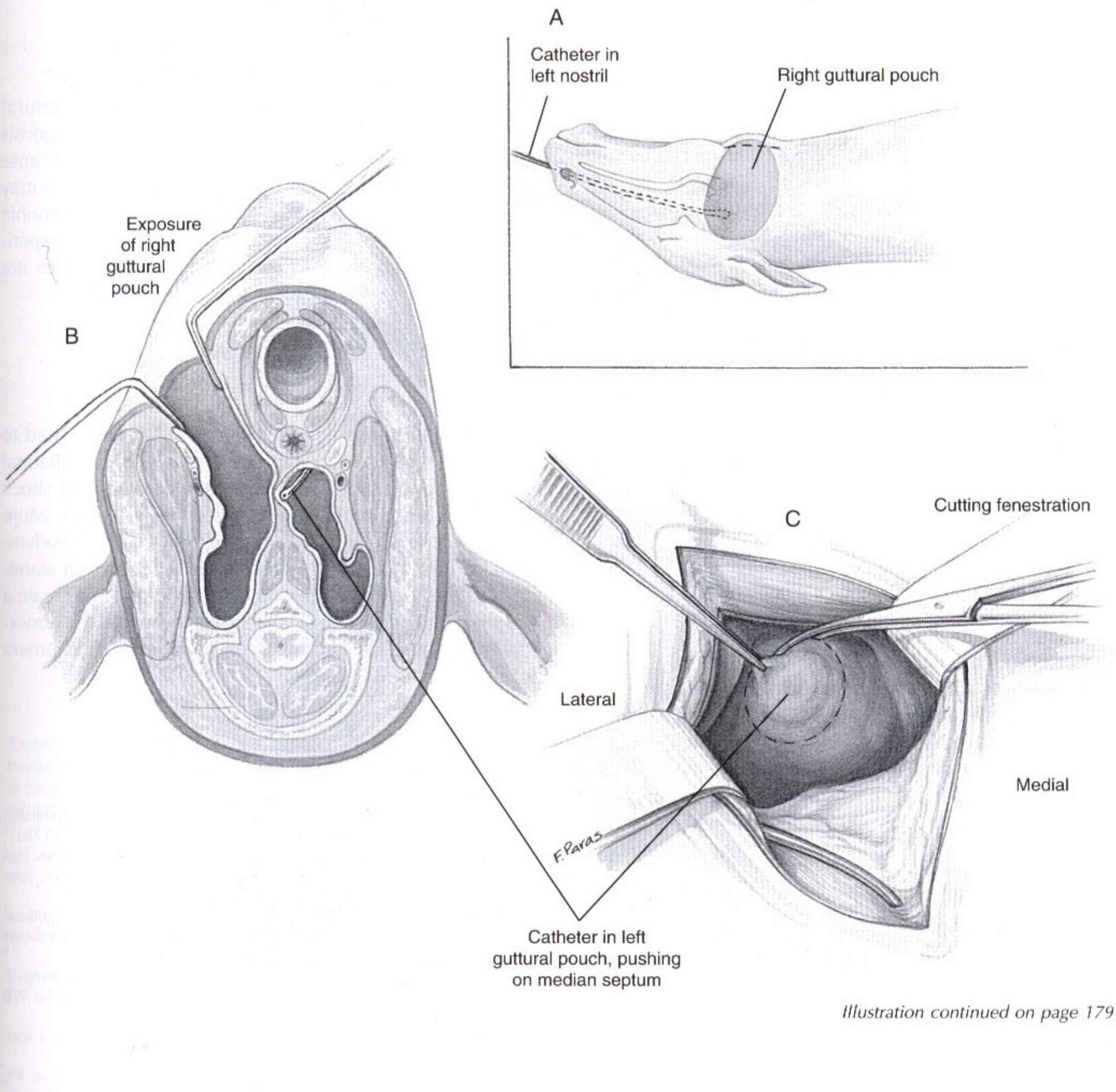


Illustration continued on page 179

The Chambers catheter is removed and reinserted into the guttural pouch on the affected side to aid in identifying the pharyngeal orifice. The pharyngeal orifice and plica salpingopharyngeus will be found medially, slightly cranially, and deep (dorsally) in the interior of the guttural pouch (Fig. 34–1*D*). The blade retractor can be positioned medially to retract the edges of the guttural pouch, aiding visualization of the internal aspect of the pharyngeal orifice and the plica salpingopharyngeus. The medial aspect of the plica salpingopharyngeus is grasped with a thumb forceps and excised with Metzenbaum scissors (Fig. 34–1*E*). A triangle-shaped piece 3 cm long × 2 cm wide should be removed. The medial laminae and cartilaginous flap are identified by digital palpation. The cartilaginous flap can be hooked with the small sharp-pronged retractor and everted from the pharynx caudally into the guttural pouch. The prongs of the rake retractor are turned medially to hook the edge of cartilaginous flap (Fig. 34–1*F*). The flap is grasped with a long Allis tissue or Ochsner forceps and stabilized in the interior of the guttural pouch. A 1 × 2-cm piece of the medial laminae is resected with Metzenbaum scissors to enlarge the pharyngeal orifice (Fig. 34–1*G*). To maintain patency of the enlarged orifice in the immediate postoperative period and to reduce the chances of postoperative scarring and stricture, an indwelling catheter is inserted into the guttural pouch and left in place for 5 to 6 days.[6]

Suitable catheters include the mushroom catheter,[c] Foley catheter,[d] or short plastic mare urinary catheter.[e] The catheters can be secured in place by affixing tape to the end and suturing the catheter to the inside of the nares. Primary closure of the guttural pouch incision may be performed if no infection is present. We prefer to let the incision heal by second intention.

Postoperative Management

The skin around the open guttural pouch incision should be cleaned daily. The operated guttural pouch should be flushed daily with 100 to 200 ml of sterile saline or balanced electrolyte solution until the catheter is removed in 5 to 6 days. Antiseptics need not be instilled into the pouch. Systemic antibiotics are continued in the postoperative period as long as needed for the treatment of pneumonia or empyema. Tetanus prophylaxis should be ensured in all foals.

[c]Pezzer drain, Bard Urological Division, Covington, GA.
[d]Foley catheter, Rüsch, Duluth, GA.
[e]Mare urinary catheter, Jorgensen Laboratories, Inc., Loveland, CO.

Prognosis

Foals with uncomplicated unilateral guttural pouch tympany have a good prognosis.[1] The prognosis for foals with bilateral tympany is less favorable because scarring and reocclusion of the pharyngeal orifice may occur.[6] Foals with dysphagia or aspiration pneumonia before surgery have a poor prognosis. Foals that experience dysphagia or dyspnea after surgery that does not resolve in several days have a grave prognosis.[6]

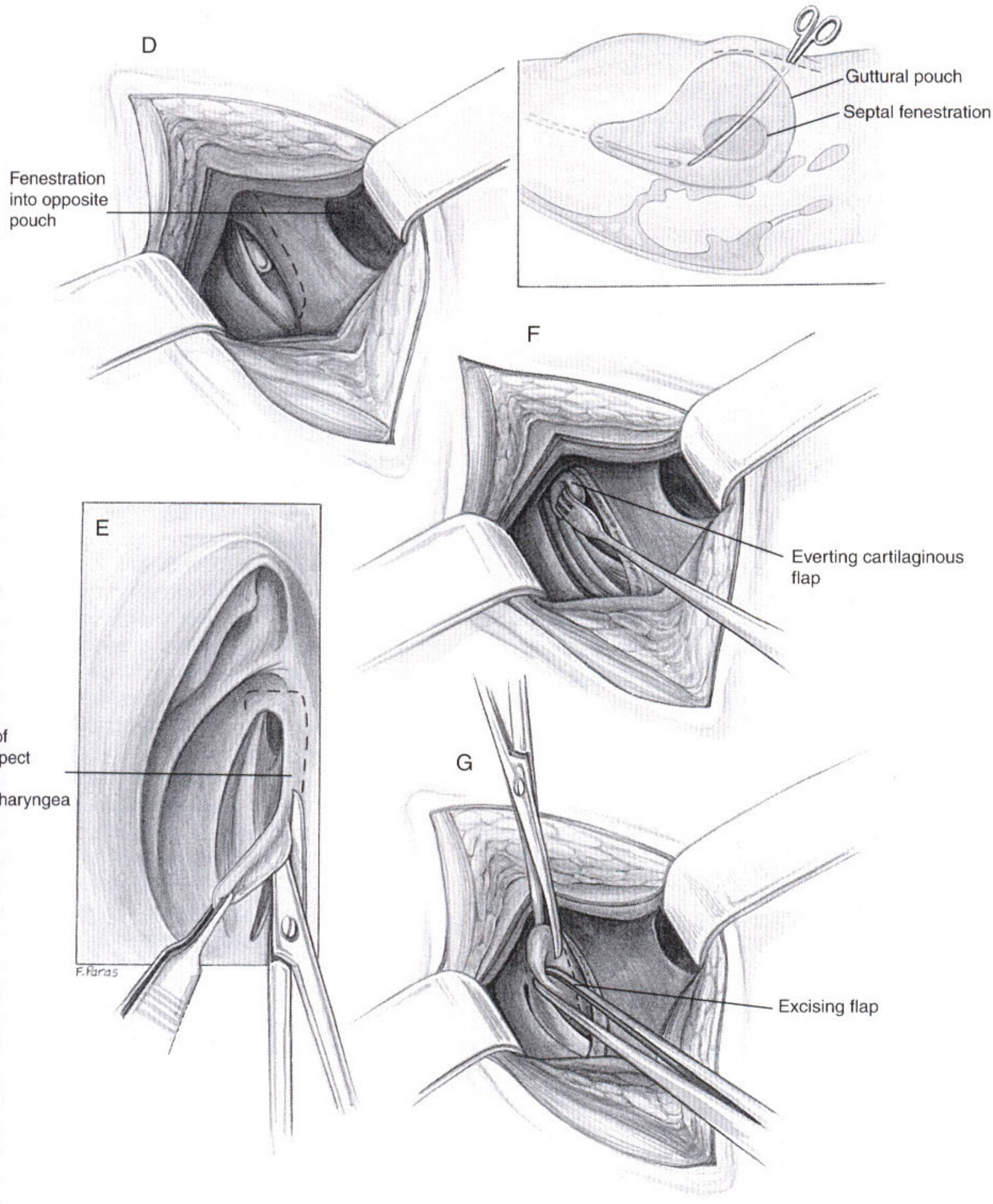
Other Treatment Methods

Transendoscopic electrocautery has been used to fenestrate the median septum in foals with unilateral guttural pouch tympany.[7] The risks of electrical shock to the patient and surgeon are not insignificant. More recently, transendoscopic application of the neodymium:yttrium aluminum garnet (Nd:YAG) laser in standing foals to fenestrate the median septum or to create a salpingopharyngeal fistula in order to bypass the abnormal pharyngeal orifice has been successful for treatment of guttural pouch tympany.[8]

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Figure 34–1. *Continued*



chapter 35

Arterial Ligation for Guttural Pouch Mycosis

Epistaxis in the horse is common, and the causes and possible sources of the blood are many. The lungs, sinuses, nasopharynx, turbinates, nasolacrimal system, and guttural pouches can all be sources of blood loss from the nose. Systemic diseases such as idiopathic thrombocytopenia can cause epistaxis. Guttural pouch mycosis occurs sporadically worldwide and must be included in the differential diagnosis of epistaxis. The hemorrhage is usually unilateral from the affected side, but the condition can be bilateral as well. The blood is typically bright red and flows freely from the nostril. Bleeding can occur spontaneously, even when the horse is at rest. Recurrent episodes of epistaxis occur. The amount of epistaxis can range from a few drops of blood to massive bleeding and death. Endoscopic examination of both eustachian tube diverticula is essential for the diagnosis of guttural pouch mycosis. Although endoscopy is essential, there are limitations. Twitching as restraint for endoscopy has been associated with fatal hemorrhage, and visibility within the guttural pouch may be poor after a recent hemorrhage.[1]

Anatomically, the eustachian tube diverticula touch a great number of nerves and vessels. The internal carotid artery, within a dorsomedial fold of membrane lining, is the most common site for a mycotic lesion to cause bleeding. The external carotid artery as well as its branch, the maxillary artery, adjacent to the lateral wall of the guttural pouch, is the second most frequent site of bleeding. The caudal auricular artery is rarely involved. The glossopharyngeal, vagus, spinal accessory, and hypoglossal nerves, as well as the cranial cervical ganglion and its postganglionic fibers, are adjacent to the membrane lining and associated with the carotid vessels. Approximately one third of all horses with guttural pouch mycosis have pharyngeal hemiplegia or paralysis, which can be the most difficult aspect of the condition to manage.[2] Laryngeal hemiplegia is the second most common ramification of a nerve deficit encountered in these cases and may require additional corrective surgery when athletic performance status is required. Depending on the nerve involved, Horner's syndrome, soft palate paresis, and, less frequently, vestibulocochlear and facial nerve dysfunction and mild colic have been associated with guttural pouch mycosis. In long-standing cases, all manner of pathologic changes have been reported, including temporohyoid and atlanto-occipital joint diseases, locomotor disturbances, visual disturbances leading to blindness, abscesses, and mycotic encephalitis.

The primary approach to treatment of guttural pouch mycosis is the control of hemorrhage. When the mycotic lesion is located in the dorsomedial aspect of the guttural pouch, this is presumptive evidence that hemorrhage has arisen from the internal carotid artery. Ligation of this vessel at its bifurcation with the external carotid is an effective means of reducing the chance of fatal epistaxis.[3, 4] The surgery should be performed on an urgent basis as soon as the diagnosis and source of hemorrhage are confirmed. The control of hemorrhage from other vessels (e.g., external carotid/maxillary) can be difficult, requiring carotid angiography to establish the exact source of bleeding.[5, 6] Multiple ligations at the external carotid trifurcation have been successful, but it must be recognized that these are not end arteries and that ligation of normograde flow does not preclude retrograde flow from the circle of Willis, which can lead to additional hemorrhage and possible death.[3, 4]

Normograde ligation of the internal carotid artery does not reduce blood pressure in the vessel,[7] but presumably, the single ligature reduces blood flow sufficiently to promote thrombosis with "starvation" of the mycotic lesion and eventual resolution of the disease. Balloon-tipped catheter arterial occlusion is used to preclude normograde and retrograde flow in both the internal and external carotid arterial complexes.[8, 9] This approach is advocated to totally eliminate the risk of subsequent hemorrhage, but the procedure is technically demanding and fraught with complications. Incisional infection, catheter breakage, inappropriate balloon positioning, catheter tip extrusion into the lumen of the guttural pouch, partial recanalization of the vessel, and the need to remove the catheter occur frequently. Although these operative complications are not life threatening, they create morbidity for the patient for which the cost-effectiveness must be compared with the relatively simpler ligation of normograde flow.

Anesthesia, Positioning, and Surgical Preparation

Horses that have sustained severe or repeated hemorrhaging develop blood loss anemia. When the packed cell volume is 25% or below, consideration should be given to cross-matching and locating a suitable blood donor before proceeding with anesthesia and surgery. General anesthesia and aseptic technique are required for the ligation procedure. The horse is positioned in lateral recumbency with the affected side up. The rare horse with bilateral guttural pouch mycosis can have both vessels ligated during the same anesthetic period, but the horse must be turned over to approach the opposite side. A liberal area of the parotid region is clipped and routinely scrubbed. Vessel ligation is a clean procedure without implants; perioperative antibiotics are unnecessary. Depending on the thickness of the horse's neck and throatlatch region, large self-retaining retractors[a] are the only special instruments required.

Surgery

A 12- to 15-cm curvilinear skin incision is made in the parotid region just above Viborg's triangle (Fig. 35–1*A*). The incision is positioned below the hyoverte-brotomy approach to the guttural pouch and continues through the cervical fascia. The ventral portion of the parotid gland is variable in this location and must be preserved and reflected cranially when it is encountered. A combination of blunt and sharp dissection is continued between the sternomandibularis tendon of insertion and the brachiocephalicus muscle. The trifurcation area of the common carotid artery is identified by palpation for a pulse.

Vascular anatomy at the trifurcation is variable. The internal carotid and occipital arteries arise in close proximity (Fig. 35–1*B*). Usually the internal carotid artery originates before the occipital artery, courses deep and rostral to the occipital artery, and is the smaller of the two branches. Occasionally, the orientation of the two vessels is reversed or a common trunk exists. Because of this variation, both arteries are routinely ligated, even bilaterally, without fear of creating neurologic deficits.[4] The external carotid artery can be ligated as well but only when there is reason to believe that it is the source of hemorrhage.

Once the vessels are identified, sharp dissection with Metzenbaum scissors, along the length of the arteries in the vascular adventitia, is done to preserve nerve structures and isolate 2 to 3 cm of vessel. The safest vascular dissection is "close to the vessel" (Fig. 35–1*C*). Size 0 or 2–0 silk[b] is used to double-ligate the internal carotid and occipital arteries without transfixation (Fig. 35–1*D*). Monofilament synthetic suture material has been used for ligation, but we prefer silk for knot security when performing vascular surgery. The guttural pouch is not entered. A three-layer closure of the incision is used. Monofilament synthetic delayed-absorbable suture[c] is used to approximate the cervical fascia and subcutaneous tissue. The skin can be closed with size 2–0 polypropylene[d] or stainless steel staples.[e] No drains are used. The incision can be protected with a self-adhering, water-repellent drape[f] during recovery from anesthesia. Postoperative bandaging is not required.

Postoperative Management

Because of the threat of a bleeding episode after surgery, the horse is confined to a stall for 2 to 4 weeks. Tetanus immunization status should be current, but other postoperative medications are not required. If the proper vessel has been occluded, the mycotic lesion in the guttural pouch resolves without specific antifungal therapy.[5, 10] Barring secondary bacterial infection arising from the mycotic disease, incision healing is uneventful. The horse is returned to performance status when follow-up endoscopic examination establishes that the mycotic lesion is resolved.

Normograde ligation significantly reduces the chances of severe or fatal hemorrhage, but these complications have been reported in one horse out of 30 after this procedure.[3] Presumably, continued bleeding is because of occlusion of the wrong vessel or because of retrograde flow. The costs and risks must be weighed when selecting simple ligation compared with balloon-tipped catheter occlusion. Even though some cases with pharyngeal hemiplegia can make a complete recovery after 12 to 18 months, recovery from this problem is not common. A major complication of normograde ligation of the external carotid artery is retinal damage and blindness.[9, 11] Because blindness has not followed balloon-tipped catheter occlusion of the external carotid, the owner should be informed of such a risk when simple ligation of this vessel is contemplated.

In summary, normograde ligation of the internal carotid artery is a relatively simple procedure that prevents hemorrhage in a large majority of horses with guttural pouch mycosis. The surgery can be conducted in most general equine surgical practices.

[a]Beckman-Adson laminectomy retractor, Baxter Healthcare Corp., Round Lake, IL.

[b]Silk, Ethicon, Inc., Somerville, NJ.

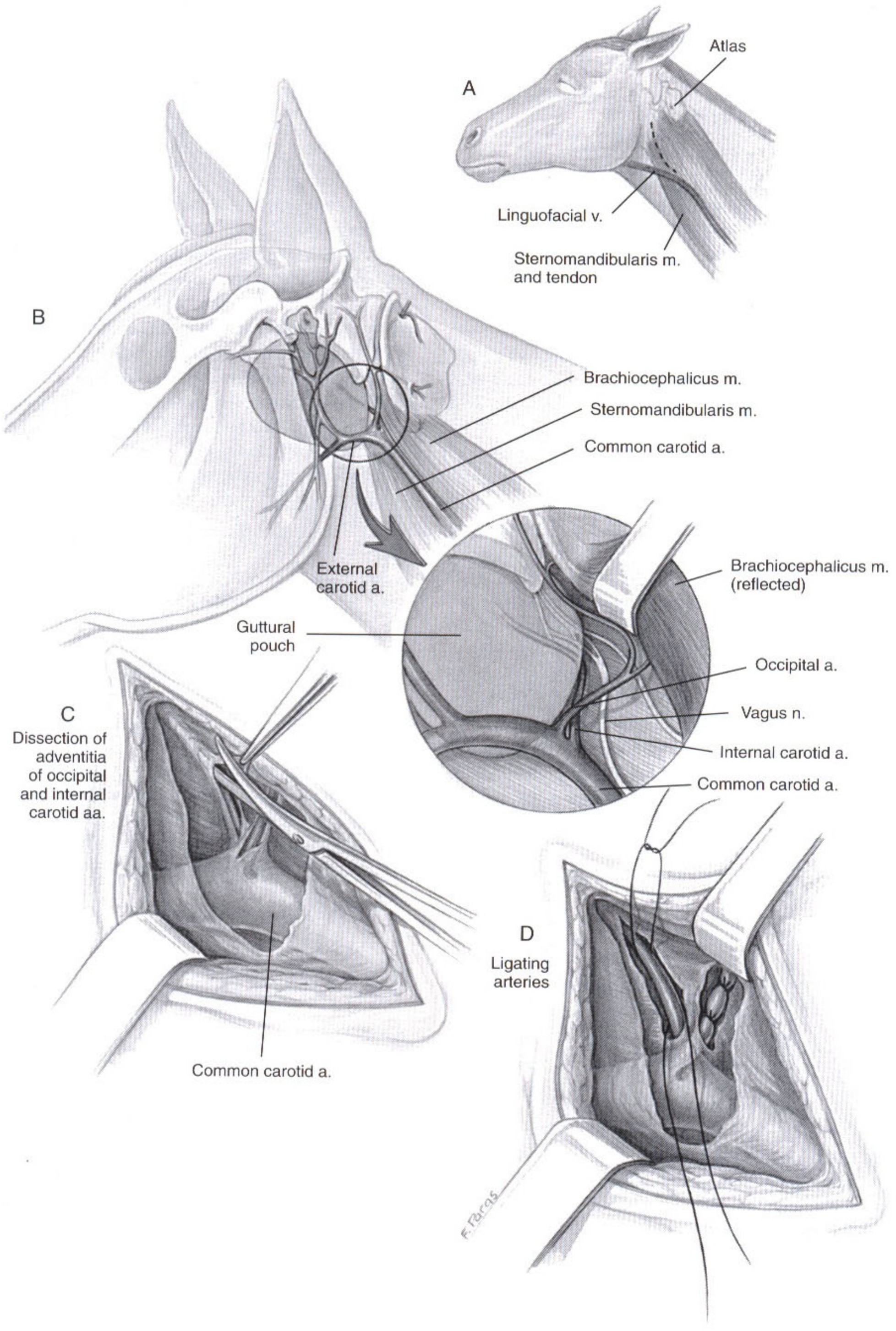
[c]PDS II, Ethicon, Inc., Somerville, NJ.

[d]Prolene, Ethicon, Inc., Somerville, NJ.

[e]Appose ULC, Davis & Geck, Inc., American Cyanamid Co., Manati, PR.

[f]Steri-Drape 2, Animal Care Products, 3M Health Care, St. Paul, MN.

Figure 35–1.


A
Atlas
Linguofacial v.
Sternomandibularis m. and tendon
B
Brachiocephalicus m.
Sternomandibularis m.
Common carotid a.
External carotid a.
Brachiocephalicus m. (reflected)
Guttural pouch
Occipital a.
Vagus n.
Internal carotid a.
Common carotid a.
C
Dissection of adventitia of occipital and internal carotid aa.
Common carotid a.
D
Ligating arteries
F. Paras

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chapter 36

Tracheotomy

Tracheotomy is performed in horses with upper respiratory tract obstruction as a life-saving measure, as a route for endotracheal intubation for general anesthesia when routine nasotracheal or orotracheal intubation limits access to the surgical field, and to physiologically rest the upper respiratory tract. Tracheotomy can also provide drainage for respiratory fluids or after aspiration of saliva and food material in choked horses. Procedures such as nasal septum resection require postoperative tracheotomy because the nasal chamber is packed with gauze for hemostasis. Little preparation is done in emergencies when the horse is dyspneic. Routine surgical preparation is appropriate for elective procedures. The surgical approach and technique are the same regardless of the indications.

Surgical Preparation and Anesthesia

If a horse is cyanotic and near collapse from respiratory embarrassment, there is no time for surgical preparation, and anesthesia is unnecessary. We have performed tracheotomies by incising the unclipped skin, bare handed and with a scalpel blade as the only available instrument; two fingers in the tracheal lumen can serve as retractors and provide an airway while a makeshift tracheotomy tube is devised or the proper instrument is obtained. Although such approaches are lifesaving, most indications for tracheotomy allow time for planning and proper preparation. The surgery is easier to perform in the standing animal with the head slightly extended. This provides the most natural anatomic positioning for landmarks of the ventral neck and trachea. However, when tracheotomy is used for endotracheal intubation, it is more convenient to prepare the site surgically, induce anesthesia, and then carefully perform the tracheotomy with the horse in lateral or dorsal recumbency and with the head extended.

The incision site is the ventral midline of the neck between the upper and middle thirds or slightly caudal, depending on the breed of horse and neck muscle development. A wide area is clipped and routinely prepared for aseptic surgery. When a problem such as laryngeal edema is a potential postoperative complication, we routinely clip the ventral neck between the jugular furrows and beyond halfway down the neck as a part of preparation for the primary surgery. Infiltration of the skin and subcutaneous tissues with up to 15 ml of local anesthetic and restraint with a twitch is usually sufficient. Chemical restraint may be necessary for fractious patients, but these drugs cause horses to drop their heads, with the trachea being positioned more deeply in the musculature. Although the surgery is clean-contaminated, once the tracheal lumen is entered, a clean approach to this surgery is appropriate when possible. Draping is unnecessary, but the surgeon should don sterile gloves and use autoclaved instruments.

Surgery

A scalpel is the only required instrument. A 6-cm-long longitudinal skin incision is made on the ventral midline of the neck at the selected site based on palpation of the tracheal rings through the skin. Longer skin incisions should be avoided because of increased wound morbidity during convalescence. Also, the flange of the tracheotomy tube fits poorly when the skin incision is too long, tending to lodge subcutaneously and contributing to the inflammation. Sharp incision is continued through the subcutaneous tissue and mesial fascia of the paired sternothyrohyoideus muscles to expose the trachea (Fig. 36–1*A*). Blunt dissection of these layers should be avoided; subcutaneous emphysema results from the unnecessary separation of tissue planes. The tracheal lumen is entered by a thrusting transverse stab incision through the ligament between two easily palpable tracheal rings. The surgeon "chokes up" on the scalpel blade in doing so to preclude detachment and loss of the blade into the tracheal lumen (Fig. 36–1*B*), to maintain orientation with the trachea, and to avoid trauma to the dorsal side of the trachea, particularly in young or small patients. Some surgeons prefer a one-piece scalpel for this surgery.[1] The quick stab incision reduces the tendency to separate the tracheal mucosa from the ligament and cartilage rings. Mucosal separation increases bleeding and may lead to granuloma formation.

With the scalpel still in the tracheal lumen, the ligament is incised from the midline in both directions approximately 120° of the ventral tracheal circumference in the adult horse to permit the entry of two fingers. A J tube[a] is inserted and tied firmly in place with two separate gauze strands threaded through the flange slots and completely encircling the neck (Fig. 36–1*C*). Care must be taken to make certain that the tube is in the lumen and has not dissected between the sternothyrohyoideus muscles and the trachea. Also, using a loose-fitting, single strand of gauze or tying the strand to the mane will increase the risk of tracheotomy tube dislodgment. The tube can be further secured by wrapping the neck with elastic adhesive tape[b] and cutting a window for the lumen. Care must be taken that the tape does not slip and occlude the J-tube lumen.

We do not remove a semicircular segment of adjacent tracheal rings, even if the tracheotomy tube is to be in place for a prolonged period.[2] Such dissection requires greater tracheal exposure, can lead to the inadvertent severing of the tracheal ring, which, because the rings are incomplete, should be avoided, and contributes to complications such as granuloma or chondroma formation. Self-retaining tracheotomy tubes may be used. In our experience, they are difficult to position and maintain in place. The first flange is simple to place in the tracheal lumen, but the second flange tends to dissect retrotracheally into the musculature. Also, the relatively small outer collar tends to become positioned subcutaneously.

[a]J Tube (trachea tube, Aesculap-Werke, Tuttlinger, Germany), Jorgensen Laboratories, Inc., Loveland, CO.

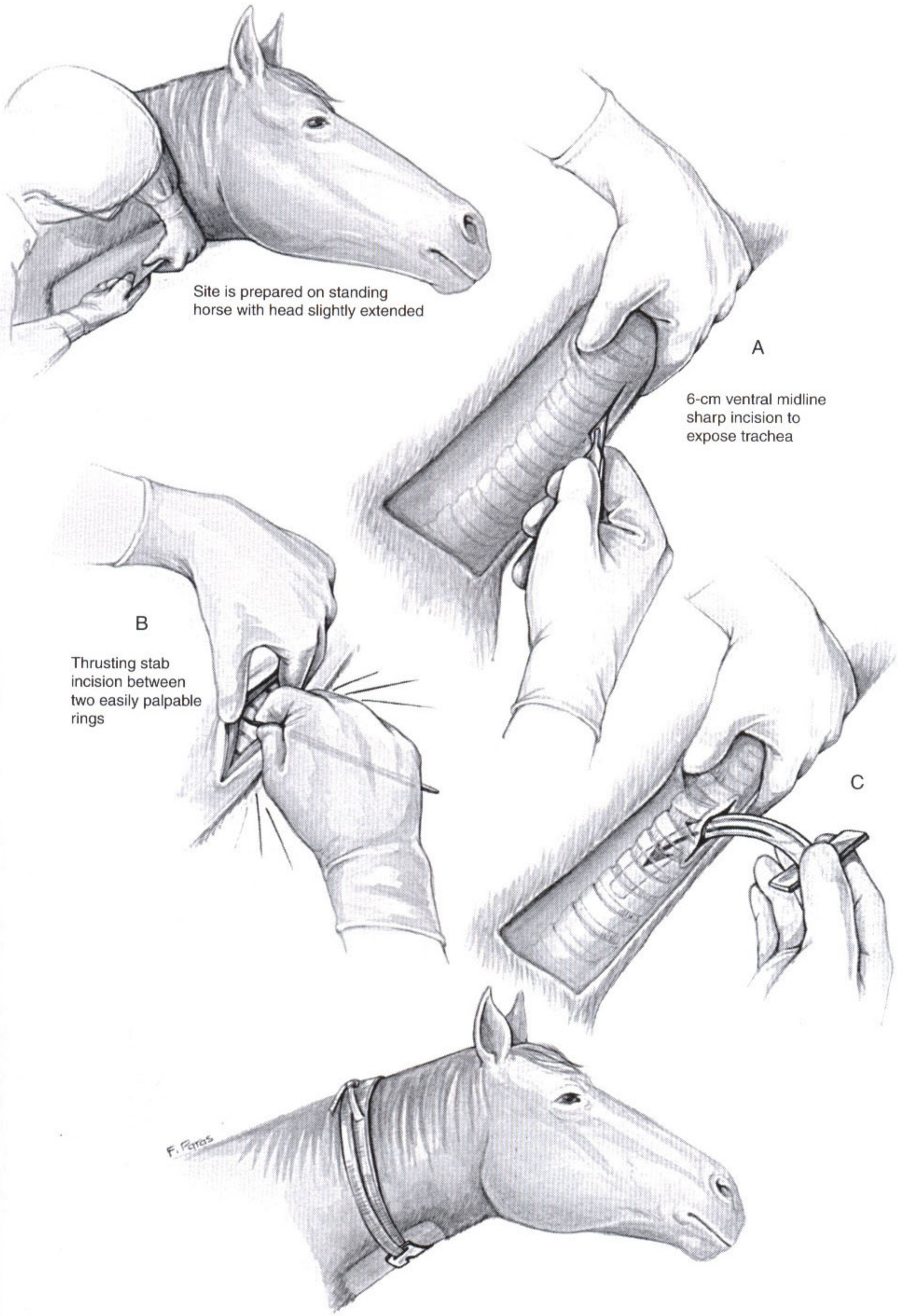
[b]Elastikon, Johnson & Johnson Medical Inc., Arlington, TX.

Postoperative Management

Tracheotomy tubes require diligent surveillance and management. The worst complication is a dislodged tube or one that is obstructed with blood clot or mucus, thus causing dyspnea. Initial bleeding may plug the tube within minutes or hours. Tracheal mucus can plug the tube in 12 to 24 hours. The tube should be changed twice daily for the first 3 days and then daily changes are sufficient. Extra J tubes must be available. A sterile tube can be inserted barehanded by touching only the outside flange, provided that the incision has been properly positioned and made (see Fig. 36–1*C*). Initial edema, then inflammation, and finally granulation tissue form a channel from the skin to the tracheal lumen, precluding the need to palpate the deeper tissues repeatedly with each tube change. Clot and mucus can be cleaned from the incision with a dry sterile sponge daily or as necessary. Washing or scrubbing the incision site should be avoided, but the exudate on surrounding skin should be cleaned off. Antibiotics may be indicated for the primary problem but are unnecessary for the tracheotomy per se. The J-tube lumen can be temporarily occluded, while air passage through the nostrils is assessed, to help decide when to remove the tracheotomy tube permanently. The site heals as an open wound within 14 to 21 days after removal of the tube. There should be no blemish.

Most complications relate to the primary disease for which the tracheotomy was indicated. Tracheotomy complications are avoided by careful attention to technique, even when the surgery is performed on the horse in duress. Bleeding from skin, or from the musculature when the incision is slightly off midline, is minor and transient. Obvious vessels can be crushed with hemostats if visibility and time allows. Tracheal mucosal bleeding is usually expelled through the J tube but may clot and plug the tube, requiring early replacement. Persistent hemorrhage should alert the surgeon to the possibility of serious technical difficulties or underlying coagulopathy in the patient. Tissue emphysema is inconsequential except when tracheotomy is performed for an infectious process (e.g., cervical phlegmon). Granulomas, chondromas, and stricture are rare but may follow an inadvertently traumatic surgical approach or prolonged maintenance of a tracheotomy tube. The trachea should be examined endoscopically 6 months or later after healing if complications are suspected. Fortunately, most tracheotomies are performed in horses for short-term purposes, and few management problems or complications occur.

Figure 36–1.


Site is prepared on standing horse with head slightly extended
A
6-cm ventral midline sharp incision to expose trachea
B
Thrusting stab incision between two easily palpable rings
C
F. Ferras

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Ophthalmic Surgery

chapter 37

Subpalpebral Lavage System Installation

The subpalpebral lavage system is an excellent means of providing frequent ocular therapy over extended periods of time. Subpalpebral lavage avoids risk of damage to the cornea from ointment tubes in head-shy horses. It simplifies treatment of horses with painful eye diseases that resent manipulation of the eye for application of topical medication, improving safety for the horse and the handler.[1, 2] Subpalpebral lavage systems can provide a means of medicating eyes after tarsorrhaphy. They are also necessary when continuous ocular medication is delivered from a reservoir by gravity or by pump.[2]

Anesthesia, Positioning, and Surgical Preparation

The horse should be sedated with xylazine or detomidine hydrochloride. Fractious horses should be twitched. The frontal nerve is blocked with 1 to 2 ml of mepivacaine hydrochloride[a] as it exits from the supraorbital foramen, using a 25-gauge, 5/8-inch-long needle. The foramen is easily palpated as a depression about 2.5 cm above the rim of the orbit (Fig. 37–1*A*). The palpebral branch of the auriculopalpebral nerve should be anesthetized as it crosses the superior margin of the zygomatic arch halfway between the eye and ear. The nerve can be identified by palpation at this point, and 5 to 10 ml of mepivacaine hydrochloride are injected directly over the nerve (see Fig. 37–1*A*). One milliliter of anesthetic should be placed subcutaneously in the upper eyelid at the two sites where the needle used to insert the catheter will penetrate the skin. Proparacaine hydrochloride[b] is instilled into the eye to anesthetize the cornea and conjunctiva. This can be done effectively using a syringe and the hub of a 25-gauge needle to squirt the anesthetic under the eyelid.

Silastic tubing (0.030-inch inside diameter and 0.065-inch outside diameter)[c] or a 5-French infant feeding tube[d] and a hubless 8- to 10-cm-long 12-gauge needle are required for installation of the subpalpebral system using a double-perforation technique. When using Silastic tubing, a 20-gauge feline indwelling catheter[e] and an injection cap are needed. The feeding tube has an injection port and cap attached. Alternatively, commercial lavage systems are available[f, g] that are installed using a trocar, which perforates the eyelid only once.

[a]Carbocaine V, The Upjohn Co., Kalamazoo, MI.

[b]Ophthetic 0.5%, Allergan America, Hormigueros, PR.

[c]Dow Corning Silastic medical grade tubing, Stortz Instrument Co., St. Louis, MO.

[d]Premature infant feeding tube, Davol Inc., Cranston, RI.

[e]Feline indwelling catheter, Sherwood Davis & Geck, St. Louis, MO.

[f]Ocular lavage kit, Cook Veterinary Products, Inc., Bloomington, IN.

[g]Subpalpebral lavage kit, Mila International, Inc., Erlanger, KY.

Surgery

The upper eyelid is elevated away from the cornea with a gloved finger, and the hubless 12-gauge needle is passed from the lateral and uppermost aspect of the conjunctiva fornix through the skin to emerge from the eyelid just rostral to the rim of the orbit. The needle is passed in a dorsolateral direction (Fig. 37–1*B*). A gauze sponge can be folded and used to push on the blunt end of the needle. The lavage tube is passed from the tip of the needle until it emerges from the hub, at which point it is grasped and held in place as the needle is pulled back out of the eyelid in a ventral direction (Fig. 37–1*C*). The 12-gauge needle next is passed from the medial and dorsal aspect of the conjunctival fornix through the skin of the upper eyelid in a dorsomedial direction using the same technique (Fig. 37–1*D*). The end of the tube in the lateral fornix is passed into the hub of the needle until it emerges from the tip. The needle and tubing are removed dorsally to leave a loop of tubing in the conjunctival fornix. The tubing should exit the skin above the eyelid 4 to 5 cm apart because the pathways of the 12-gauge needle through the fornix and skin diverge (Fig. 37–1*E*). The end of the tubing that emerges from the medial aspect of the eyelid is tied on itself with several knots to prevent it from slipping into the conjunctival fornix and damaging the eye. The lateral end of the tube is pulled to take the slack out of the loop in the conjunctival fornix and to position the knot against the skin of the upper eyelid. The knot is then pulled back slightly, and the tube is folded over so the knot lies adjacent to the lateral portal; this helps to determine the portion of tubing that will be in the conjunctival fornix. The center of the loop of tube within the conjunctival fornix is perforated with two or three through-and-through holes using a 22-gauge needle. These holes should be spaced closely together so they remain within the conjunctival fornix when the tube is in the correct position. Failure to ensure that all holes are within the fornix often results in leakage of medication into the subcutaneous tissues of the eyelid. The end of the tube is then pulled so the knot is against the skin (Fig. 37–1*F*).

The tube is palpated to ensure that it is positioned properly in the dorsal conjunctival fornix and does not rub on the cornea. The tube is secured to the head of the horse by attaching adhesive tape butterflies adjacent to the lateral exit hole, halfway between the eye and the poll,[h] and at the base of the forelock. The tape can be glued or sutured to the skin. The tube is passed through a braided forelock and along the crest of the neck through braids in the mane. An injection portal is made for the Silastic tubing by inserting the feline catheter 1 cm into the free end of the tubing and putting an injection cap on the other end of the catheter. The catheter and injection cap can be secured with glue or by taping the catheter and tube to a tongue depressor.

Commercial subpalpebral lavage systems are usually placed by using a trocar to perforate the eyelid. The tube is maintained in the eye by having a flange or soft plate on the end of the tube within the conjunctival fornix. A single perforation of the eyelid is done, usually in the dorsolateral aspect of the fornix.

Postoperative Management

Tetanus prophylaxis should be ensured. The tube should be checked frequently to ensure that it remains properly positioned. Loose tubes may result in corneal irritation or subcutaneous injection of medication. Tape butterflies that become loose should be replaced. The eyelid should be observed for severe swelling, which suggests subcutaneous instillation of medication. Rarely, infection of the eyelid may occur.

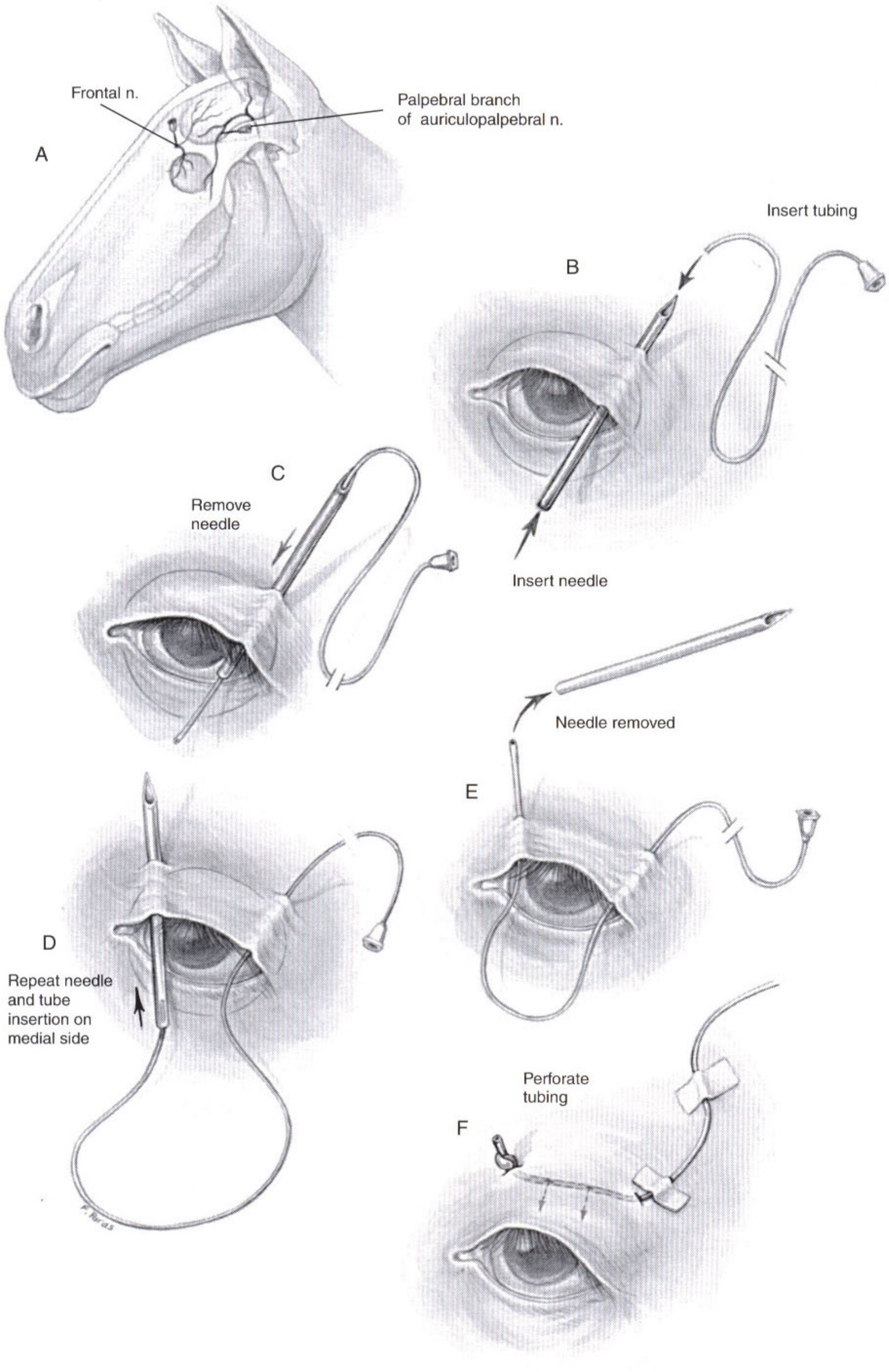
Medications can be injected through the catheter as often as is desired or continuously. Small volumes of medication can be instilled in the eye by flushing the catheter with 2 or 3 ml of air. An alternative to the subpalpebral lavage system is the installation of a nasolacrimal cannula.[2]

[h]Superglue, Loctite Corp., Cleveland, OH.

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Figure 37–1.


Frontal n.
Palpebral branch
of auriculopalpebral n.
A
Insert tubing
B
Insert needle
C
Remove
needle
Needle removed
E
D
Repeat needle
and tube
insertion on
medial side
Perforate
tubing
F

chapter 38

Entropion Surgery

Entropion is the inward rolling of the eyelid, resulting in rubbing of cilia and facial hairs on the cornea. This irritation causes blepharospasm and excessive tearing and, when left untreated, may lead to keratitis and corneal ulcers. Infrequently, entropion occurs in older horses from trauma and cicatrix formation.[1] Entropion is most common in the lower eyelid of young foals and rarely may be hereditary.[1, 2] Most often, entropion occurs in malnourished, dehydrated, or septicemic foals, and the condition resolves as these foals are hydrated and nourished and sepsis is eliminated. However, temporary eversion of the eyelid can be useful in the interim, while the foal is regaining health, to avoid ocular complications. Manual repositioning of the eyelids, repeated as often as needed, and the instillation of ophthalmic ointment may be sufficient in foals with mild entropion. Temporary eversion can be achieved by injecting 0.5 to 1 ml of procaine penicillin G[a] into the base of the affected eyelid using a 20-gauge needle. The medication is massaged toward the eyelid margin to produce a swelling, which may reposition the inwardly rolled eyelid for up to 48 hours.[1] Alternatively, temporary everting Lembert sutures can be placed in the lower eyelid to correct the entropion while the primary problems are being treated.[1, 2] Reconstructive surgery should be reserved for severe entropion in foals that does not respond to temporary eversion techniques and for entropion in adult horses caused by cicatrix.[1, 2] Reconstructive surgery in young foals, in which entropion is secondary to malnutrition, dehydration, and sepsis, may result in overcorrection of the entropion as the foal regains health and grows.

[a]Crysticillin 300, A.S. Solvay Animal Health, Inc., Mendota Heights, MN.

Anesthesia, Positioning, and Surgical Preparation

The temporary eversion techniques for treatment of entropion in foals requires sedation and manual restraint. Reconstructive surgery is easiest to accomplish with the patient under general anesthesia. After anesthesia, the cornea should be lubricated with ophthalmic ointment and the hair removed from the lower eyelid; one should be careful not to get clipped hair into the conjunctival sac of the eye.

Surgery

Everting Suture

Interrupted Lembert sutures using size 3–0 or 4–0 nylon[b] or polypropylene[c] suture materials are placed in the lower eyelid along the area of inversion (Fig. 38–1*A*). The sutures are placed perpendicular to the eyelid margin. Two or more sutures should be used depending on the severity of the entropion. The sutures should be placed close to the eyelid margin. Bites should be of sufficient size to correct the entropion but not result in eversion. Preplacement of the sutures before tying knots allows equal distribution of tension and assessment of the effect on inversion. Bites that are too large or too small can be reset. The Lembert sutures should not be pulled tight. The sutures are intended to correct the entropion temporarily by gently inverting a fold of skin of the eyelid while predisposing diseases are being treated. Sutures are removed in 7 to 10 days.

Reconstructive Surgery

The Hotz-Celsus technique is used for permanent correction of entropion.[3] A crescent-shaped section of skin and the underlying orbicularis oculi muscle are removed from the affected eyelid. Using a no. 15 scalpel blade, the first incision is made parallel with and about 3 mm from the eyelid margin. A second, more ventral elliptic incision connected to the ends of the first incision is made so that a crescent-shaped island of skin is formed (Fig. 38–1*B*). The length and width of the crescent should be determined by observation and manipulation of the eyelid before surgery because anesthesia may change the spatial relationship of the eyelids and globe. Scissors are used to dissect free the island of skin and underlying orbicularis oculi muscle. Hemorrhage can be controlled with gentle digital pressure or 1:10,000 solution of epinephrine. A single layer of simple interrupted sutures using size 3–0 or 4–0 nylon or polypropylene suture material placed in the skin is used to close the wound (Fig. 38–1*C*). Sutures are removed no later than 10 days after surgery.

Postoperative Management

Keratitis, corneal abrasions, and corneal ulcers should be treated with appropriate ophthalmic medications until resolved.

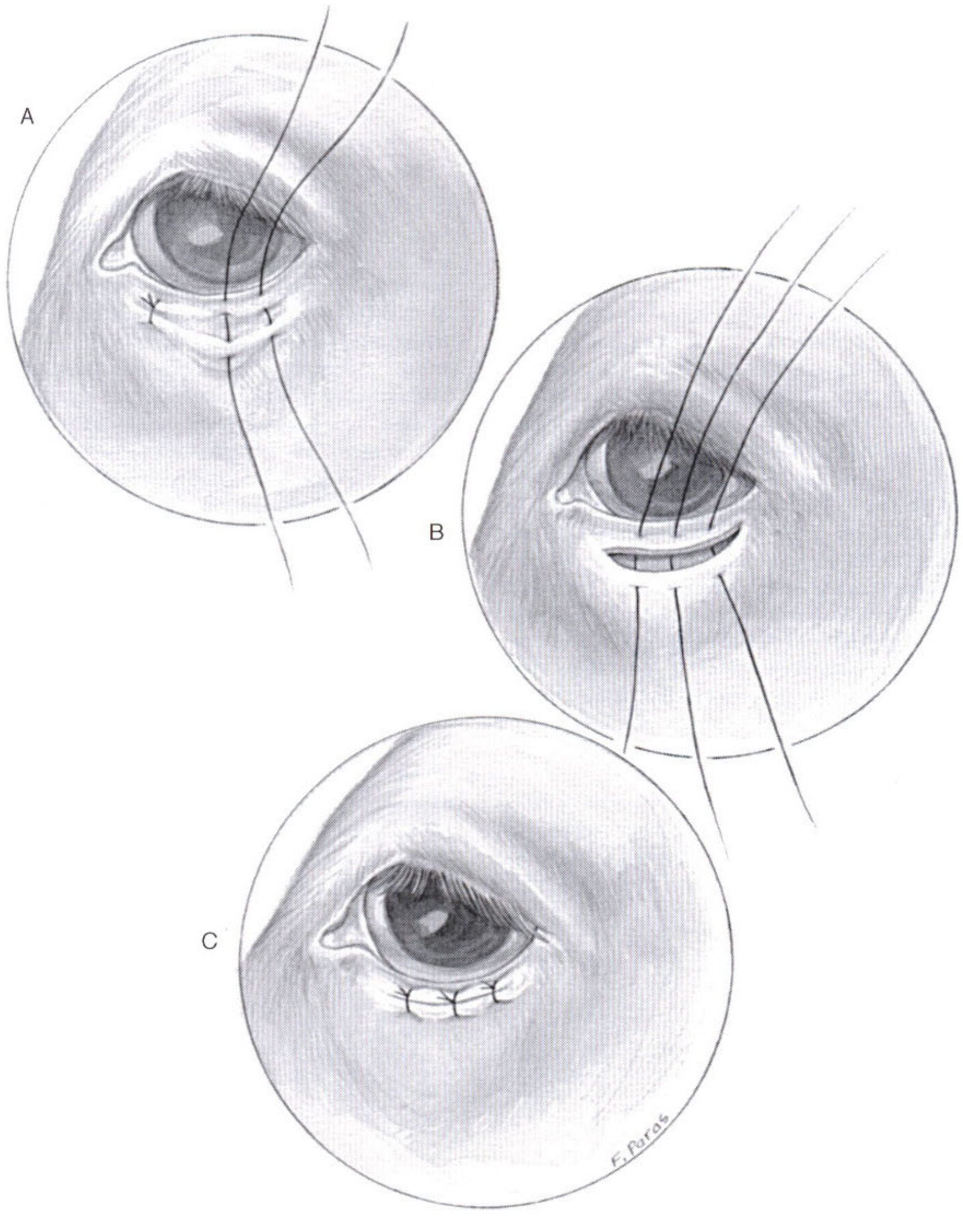
[b]Dermalon, Davis & Geck, Inc., American Cyanamid Co., Manati, PR.

[c]Prolene, Ethicon, Inc., Somerville, NJ.

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Figure 38–1.



chapter 39

Third Eyelid Excision

The most common site for ocular squamous cell carcinoma is the third eyelid.[1,2] Draft breeds and Appaloosas have a significantly greater prevalence of this tumor than other breeds with darker hair color.[3] When detected early, third eyelid excision is a definitive treatment for cancer in this location. Squamous cell carcinomas may arise with almost the same frequency on the eyelids, the bulbar conjunctiva, or the corneal limbus. Squamous cell carcinoma involving the eye and its adnexa recur in 30% of the cases and have been known to metastasize to regional lymph nodes, salivary glands, and lungs.[1,2] Adjunctive therapy, including cryotherapy, beta irradiation, hyperthermia, and laser ablation, can be combined with third eyelid excision in an effort to control squamous cell carcinoma, particularly if the condition recurs. Other less common tumors of the third eyelid, such as melanomas and papillomas, and, rarely, injuries may be managed by excision. The caruncle at the medial canthus can be involved with neoplasia or may be objectionably prominent and hairy. It can be removed along with the third eyelid.

The functions of the third eyelid, or membrana nictitans, are uncertain. The third eyelid has an irregularly shaped core of elastic cartilage and glandular tissue that is covered by vascular areolar tissue and conjunctiva. The bulbar surface of conjunctiva covering the third eyelid may contain lymphoid tissue. Goblet cells at the base contribute a mucous component to lacrimal secretion. In addition to contributions to tear formation, immune functions and physical protection have been attributed to the third eyelid. It has been used as a flap to cover and protect corneal lesions, but it has limited usefulness in this regard and should not be preserved for this purpose alone. We prefer conjunctival flaps or tarsorrhaphy when corneal protection is needed. There are no apparent pathophysiologic consequences to third eyelid removal.

The deep limits of the third eyelid should be examined carefully when selecting cases for third eyelid excision. This is best done by palpation with a well-lubricated gloved finger after topical anesthesia of the cornea. Prominence or protrusion of the third eyelid may occur because of retrobulbar masses such as lymphosarcoma or deep invasion by squamous cell carcinoma. Small lesions on the free margin of the third eyelid can be resected followed by suture of the conjunctiva over the exposed cartilage, but we prefer to err in favor of complete excision if there is any question about the margins or extent of the disease. Retrobulbar disease or tumors that have spread beyond the limits of the third eyelid require other treatments in addition to third eyelid excision.

Anesthesia, Positioning, and Surgical Preparation

The third eyelid can be resected in the standing horse by using a combination of chemical restraint, regional anesthesia, topical anesthesia of the cornea and conjunctiva, and local infiltration of the base of the third eyelid. Xylazine hydrochloride[a] provides suitable sedation. Topical proparacaine hydrochloride[b] is used to desensitize the cornea and conjunctiva. Several instillations of proparacaine drops applied over 10 to 15 minutes should be used to ensure good topical anesthesia. A 20-gauge, 1½-inch needle is used to inject 10 ml of mepivacaine hydrochloride[c] under the base of the third eyelid (Fig. 39–1*A*). The volume of anesthetic solution helps to elevate the third eyelid from the orbit. This combination of topical and local anesthesia is all that is necessary for many horses. Regional anesthesia of the supraorbital and auriculopalpebral nerves to paralyze the orbicularis oculi muscle may be helpful in some horses. If the caruncle at the medial canthus is to be removed at the same time, or when adjunctive therapy is used, general anesthesia is recommended for the surgery. Clipping of hair and eyelashes from the eyelids is optional. The conjunctival sac is flushed with sterile polyionic solution, and the eyelids are carefully swabbed with dilute 1:10 povidone-iodine solution[d] and cotton balls. Care is taken to keep the iodine solution out of the eye, and povidone-iodine scrub is never used. No special instruments are required for third eyelid resection.

Surgery

The surgeon should be careful not to damage the cornea. The free margin of the third eyelid is grasped with an Allis tissue forceps, elevated from the cornea, and forcibly retracted from the orbit to expose the bulbar surface (Fig. 39–1*B*). This provides a final opportunity to inspect and palpate the disease margins. Two large curved Kelly forceps with the points facing each other are clamped deep to the cartilage, the glandular tissue, and the lesion to be resected (see Fig. 39–1*B*). When possible, the eyelid is resected with blunt-blunt Mayo scissors peripheral to the Kelly forceps. All of the cartilage component of the third eyelid should be removed if possible (see Fig. 39–1*B*). If the margin of diseased tissue is uncertain, the third eyelid can be resected proximal to the forceps. Hemorrhage at this location is copious but easily controlled with digital pressure applied for several minutes. When the disease margins are questionable, suspicious tags of conjunctiva can be trimmed away. If periorbital fat is exposed at the medial canthus, it should be resected back to the conjunctival margins. No suturing is necessary, but the conjunctival edges can be apposed with fine, size 4–0 to 6–0 absorbable suture material if the horse is under general anesthesia.

Postoperative Management

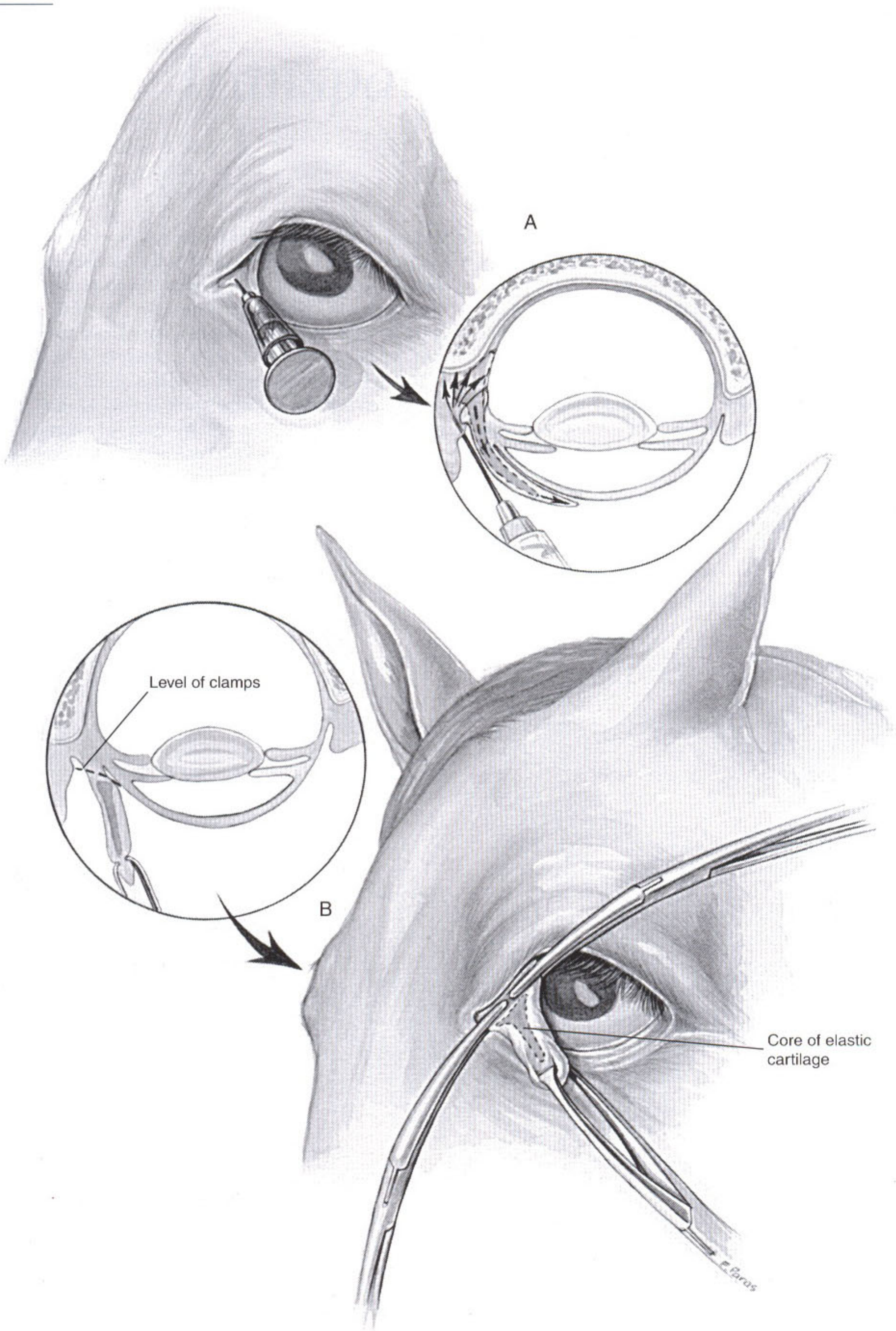
Antibiotic ointment is instilled in the eye two or three times a day for 3 days. If periorbital fat has been exposed and traumatized, systemic antibiotics are indicated. Except for hemorrhage and prolapse of fat, complications of the surgery are minimal. If the cartilage component of the third eyelid is not completely removed or is not covered by sutured conjunctiva, the exposed remnant of cartilage could damage the cornea. The resected tissues should be submitted for histopathologic analysis. Microbiologic examination of resected tissues may be indicated for certain cases. In the case of neoplasia, the horse should be re-evaluated periodically for recurrences. Because of the recurrence rate, resection of the third eyelid should be viewed as a treatment rather than a cure for squamous cell carcinoma.[3]

[a]Rompun, Miles Inc., Shawnee Mission, KS.
[b]Ophthetic, Allergan America, Hormigueros, PR.
[c]Carbocaine V, Sterling Drug, Inc., McPherson, KS.
[d]Betadine solution, Purdue Frederick Co., Norwalk, CT.

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Figure 39–1.



chapter 40

Transpalpebral Enucleation

Enucleation is a common ocular surgical procedure. It is indicated after serious trauma to the eye or when neoplasia or panophthalmitis is refractory to less invasive treatment. Also, medical treatment of corneal disease, anterior uveitis, or glaucoma can fail, leaving an eye that is chronically painful, phthisical, or microphthalmic. Enucleation is indicated in these circumstances. Transpalpebral enucleation is effective and relatively simple to perform. It is used when there is conjunctival, corneal, or intraocular neoplasia or refractory infection of these structures (i.e., when the affected tissues must be removed without contamination of remaining tissues).

Anesthesia, Positioning, and Surgical Preparation

General anesthesia is required for enucleation. Inhalation anesthesia provides the greatest flexibility and safety, but extended intravenous anesthesia can be used because the operative time is usually 45 minutes or less. The horse is positioned in lateral recumbency with the affected eye up, and the orbital area is clipped, including removal of the eyelashes. The eyelids and surrounding region are scrubbed for surgery in a routine manner. Special protection of the cornea and conjunctiva is unnecessary because they will be resected. Standard aseptic precautions are practiced, particularly if an orbital implant is used to improve the cosmetic result.[1] Perioperative antibiotics are indicated.

Surgery

Transpalpebral enucleation involves en bloc excision of the globe, eyelid margins, lacrimal gland, conjunctival sac, and membrana nictitans.[2] The eyelids are sutured or stapled closed to seal the conjunctival sac for removal. Using a no. 15 scalpel blade,[a] the eyelid skin is incised around the entire palpebral fissure 3 to 5 mm peripheral to the margins, just beyond the hair follicles and tarsal glands located in the borders of the lids (Fig. 40–1*A*). Excision of wide margins around the palpebral fissure may preclude suture apposition and primary healing of the remaining eyelids. The incisions in the upper and lower lids are connected at the medial and lateral canthi, where the skin is less mobile. With traction on the lid margins, blunt-sharp dissection with Metzenbaum scissors[b] is used to free the skin from the conjunctiva deeply to the periorbital fascia around the bony orbit (Fig. 40–1*B*). The medial and lateral canthal ligaments are tough and closely adherent to the bony orbit. They are transected with heavy Mayo scissors[c] positioned on the bone; care is taken to avoid puncture of the conjunctival sac at this stage of dissection (Fig. 40–1*C*). Large malar vessels at the medial canthus bleed profusely when cut with the canthal ligaments. They can be avoided by not "diving deeply" into the orbit with scissors. The periorbital fascia is transected for 360° around the bony rim of the orbit using Mayo scissors with one blade within and one blade outside the orbit (Fig. 40–1*D*). If bleeding or fat precludes visualization, the fascia can be palpated and incised with the scissor blades kept close to the orbital bony rim.

Fully curved Mayo-type scissors[d] are used to excise the straight and oblique ocular muscles and the retractor oculi muscle. Depending on visualization, the muscles can be transected individually or collectively, with the curved scissors kept close to the deep contour of the globe (Fig. 40–1*E*). This part of the dissection can be conservative, with muscles being transected near the globe and leaving considerable tissue in the orbit; or if periocular disease exists, the dissection can lead to exenteration of the orbit. The vessels accompanying the optic nerve are variable. Some surgeons prefer to cross-clamp the vessels before transection. Intraoperative bleeding can be nominal or severe when the optic nerve and vessels are transected. Hemorrhage tends to be less when dissection is close to the globe. An attempt should be made to ligate the nerve and vessels, particularly if an orbital implant is planned, but this is not always successful.[3] The globe, lacrimal gland, and associated structures are removed.

Closure consists of a complete, permanent tarsorrhaphy. A silicone orbital implant[e] improves the cosmetic outcome and is placed in the orbit before closure.[1–3] Implants are not recommended in orbits with neoplasia, infection, or chronic inflammation.[1] When used, the implant must be properly sized (30–47 mm available) to fill the orbit and trimmed and flattened on the exterior face. Hemorrhage must be controlled, and intraorbital (potassium penicillin) and parenteral antibiotics are used to decrease the risk of postoperative implant extrusion because of infection within the first 3 weeks.[1, 2] The tarsorrhaphy must result in primary healing if an orbital implant is to be successful. Size 0 polydioxanone is used to approximate redundant orbital tissue over the implant before skin closure. The remaining eyelid margins are sutured with size 2–0 polypropylene[f] using simple interrupted or vertical mattress sutures. The dermal and epidermal components of the margins must be carefully apposed to facilitate primary healing. Packing of the orbit to control hemorrhage is contraindicated if an orbital prosthesis is used. Packing is seldom, if ever, required in the horse; hemorrhage is usually controllable by other means.

Postoperative Management

A pressure bandage is applied for 3 to 5 days to decrease the tendency for hematoma formation, which could predispose to infection. Parenteral antibiotics are continued for 5 to 7 days in those patients with preexisting infection. Antibiotics are believed to be important in helping to prevent ocular implant extrusion.[1, 2] The use of nonsteroidal anti-inflammatory drugs is optional. A blood-stained nasal discharge, arising from the severed nasolacrimal system, is common after enucleation; otherwise, complications are few. Most horses adapt readily to the loss of vision in one eye and can be returned to their previous use.[3] Horses that do not receive an orbital implant have a poorer cosmetic result. The scar contracts, with sinking of the permanent tarsorrhaphy into the orbit, leaving a shelf for the accumulation of dust and hair.

Intraocular prostheses and corneoscleral prostheses have been used in the horse when enhanced cosmesis is desired.[1] These prostheses require subconjunctival instead of transpalpebral enucleation. The use of intraocular prostheses involves strict criteria for case selection, including intact ocular tissues, critical sizing,

[a]Bard-Parker surgical blades, Becton Dickinson AcuteCare Division, Franklin Lakes, NJ.

[b]Metzenbaum dissecting scissors, Baxter Healthcare Corp., Round Lake, IL.

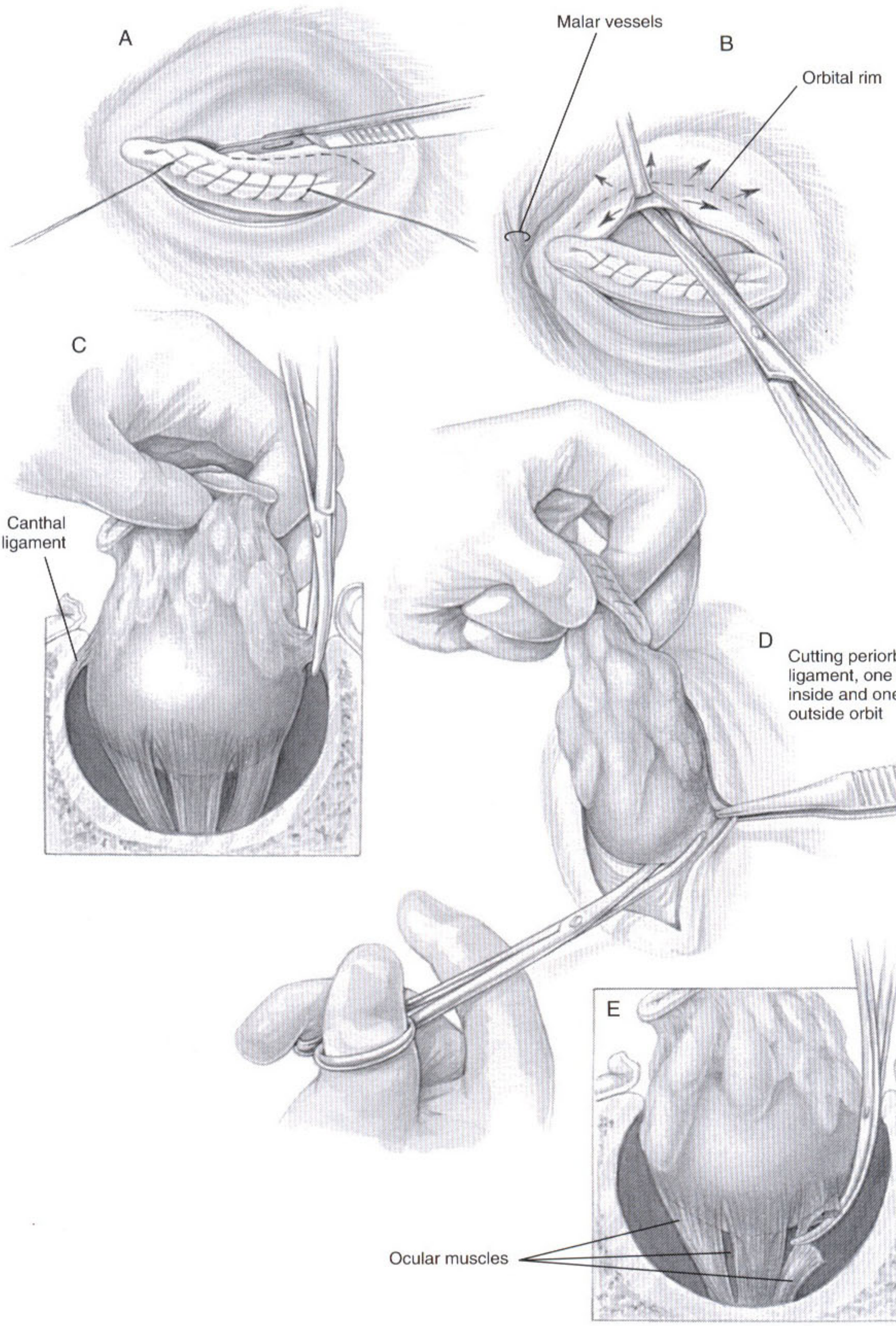
[c]Mayo dissecting scissors, Baxter Healthcare Corp., Round Lake, IL.

[d]Jorgenson scissors, Baxter Healthcare Corp., Round Lake, IL.

[e]Silicone orbital prosthesis, Jardon Institute for Eye Care, Southfield, MI.

[f]Prolene, Ethicon, Inc., Somerville, NJ.

Figure 40–1.


A
Malar vessels
B
Orbital rim
C
Canthal ligament
D
Cutting periorbital ligament, one blade inside and one blade outside orbit
E
Ocular muscles

and precise operative techniques that preclude corneal damage before or during surgery. Corneoscleral prostheses are expensive and require liaison with an optometrist. For these reasons, subconjunctival enucleation and the use of intraocular or corneoscleral prostheses should be done by, or involve close consultation with, a qualified veterinary ophthalmologist who is familiar with equine patients.

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chapter 41

Correction of Congenital Nasolacrimal Duct Atresia

Congenital atresia of the nasolacrimal duct is rarely encountered in the horse but is easily managed in most cases when it does occur. The atresia can occur anywhere along the course of the nasolacrimal duct system but is most common at the distal punctum on the floor of the nasal meatus.[1, 2] The condition can be bilateral[3] but is usually unilateral. Obstruction of the nasolacrimal system is characterized by epiphora and mucopurulent ocular discharge. The purulent component of the discharge results from the secondary dacryocystitis that develops. Staining of the face with tears may not be recognized for weeks or months after birth because of lower tear volume in neonates. Owners may not seek veterinary attention until dacryocystitis changes the character of the ocular discharge. We, and others,[3] have been presented with young but full-grown horses with atresia. This delayed onset of signs, or late presentation of the patient, suggests an acquired condition rather than a congenital anomaly. Epiphora from acquired obstruction of the nasolacrimal ducts can accompany *Thelazia* eye worms and trauma or can be secondary to alveolar periostitis, chronic sinusitis, neoplasia, and other problems that deform the face.

The history and physical examination differentiate congenital from acquired obstruction of the ducts. The upper and lower eyelids and the inside of the nasal meatus are bilaterally inspected for the presence or absence of nasolacrimal puncta. When the duct is complete except for the distal punctum, pressure on the floor of the nasal meatus may cause a backflow in the duct with an increased ocular discharge. It may be possible to see or palpate the distended duct. When the distal punctum is present, fluorescein dye staining can be used to confirm the patency of the partially occluded but otherwise intact nasolacrimal system. The clinical diagnosis of atresia is confirmed by catheterization and distention of the occluded duct. Dacryocystorhinography is indicated when the simpler tests fail to provide a diagnosis.[1, 2, 4]

Anesthesia, Positioning, and Surgical Preparation

Catheterization of the lacrimal puncta and lavage of the duct system, contrast dacryocystorhinography, and surgical correction of the straightforward cases can be accomplished in the standing horse using topical ophthalmic anesthesia and chemical restraint. Catheterization of the puncta at the medial canthus can be tedious in some horses. The surgery should be as atraumatic as possible to reduce stricture formation at the new, surgically created mucocutaneous orifice. Also, occasionally it is necessary to try catheterization of both upper and lower eyelid puncta and canaliculi before the catheter will advance beyond the lacrimal sac and continue to the rostral limits of nasolacrimal duct. For these reasons, we prefer general anesthesia.

Once the patient is suitably sedated and restrained or anesthetized, the conjunctival sac of the involved eye is lavaged with a 1% Betadine solution,[a] and the nostril, false nostril, nasal meatus, and rostral turbinate area are washed with a surgical soap and rinsed with sterile polyionic solution. Vigorous scrubbing or harsh disinfectants that could create hyperemia or bleeding of the nasal mucosa should be avoided. The nasolacrimal duct system is cannulated with the largest-sized polyethylene catheter (2.42 mm)[b] that can be atraumatically introduced into the puncta (Fig. 41–1*A*). The catheter should be advanced as far rostrally as possible. The duct system is lavaged with sterile solution until the backflush from the lacrimal puncta is free of purulent debris. Depending on the severity of the secondary dacryocystitis, culture and sensitivity testing of the pus with appropriate topical and parenteral antibiotic therapy may be indicated.

Surgery

The surgery constitutes the use of the polyethylene catheter as a retention stent until epithelization of the duct lining and nasal mucosa form a permanent mucocutaneous junction. The catheter is exposed by palpating the distal end under the mucosa and making a 3- to 4-mm incision through the mucosa with a no. 15 scalpel blade[c] directly over the catheter tip (Fig. 41–1*B*). Sponge pressure can be used to control hemorrhage. A sponge dampened with 1:1000 epinephrine may be helpful. Electrocoagulation should be avoided because it tends to delay healing and aggravate stricture formation. Once exposed, the catheter tip is threaded into the false nostril using an oversized hypodermic needle and sutured to the skin at the nostril and medial canthus (Fig. 41–1*C*). Alternatively, the ends of the catheter are tied together as a continuous loop on the outside of the face. Final lavage is performed through the lacrimal punctum of the opposite eyelid, and the face is bandaged if a continuous loop of catheter is exposed (see Fig. 41–1*C*). No effort should be made to suture the duct lining to the mucosal incision. Sutures tend to cause stricture compared with the spontaneous healing of the epithelial tissues around a retention stent.

The inability to identify the distal end of the duct encasing the catheter creates a dilemma. Blind attempts to incise over the distal tip when it can be palpated, but not seen, in the ventral turbinate region may be successful[2] but may lead to disrupted nasal mucosa and hemorrhage, which precludes further manipulation. A stainless steel wire used as a stylet within the polyethylene catheter can puncture the mucosa and guide the catheter to the outside (Fig. 41–1*D*). When these techniques fail, dacryoconjunctivorhinostomy in the malar region is a possible means of providing permanent drainage of the duct system.[1, 2]

Postoperative Management

Topical ophthalmic antibiotic or antibiotic-corticosteroid preparations can be used four times daily until the catheter retention stent is removed or the dacryocystitis subsides. Postoperative use of parenteral antibiotics, if indicated, should be guided by culture and sensitivity testing. The stent is left in place until epithelialization is complete but not so long that foreign body reaction further aggravates the dacryocystitis. We leave the stent in place for at least 14 days but no longer than 21 days, depending on the difficulties at the time of placement.[3] These patients tolerate the stent well. The prognosis is favorable for the formation of a new distal punctum.

[a]Betadine solution, Purdue Frederick Co., Norwalk, CT.

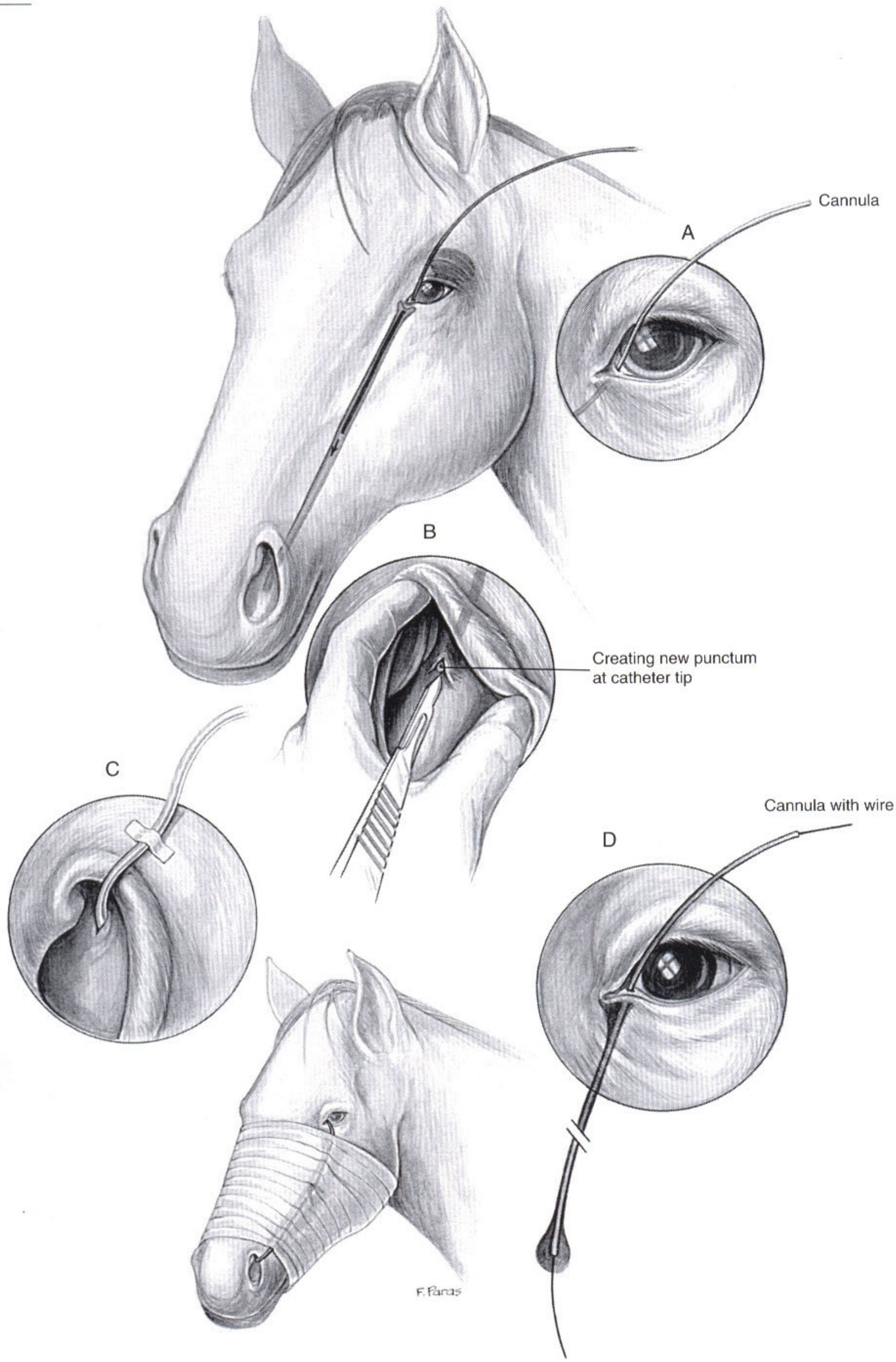
[b]Intramedic, Becton Dickinson AcuteCare Division, Franklin Lakes, NJ.

[c]Bard-Parker surgical blades, Becton Dickinson AcuteCare Division, Franklin Lakes, NJ.

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4. Latimer CA, Wyman M, Diesem CD, et al: Radiography and gross anatomy of the nasolacrimal duct of the horse. Am J Vet Res 1984;45(3):451.

Figure 41–1.


Cannula
A
B
Creating new punctum
at catheter tip
C
Cannula with wire
D
F. Parras

Male Reproductive System Surgery

chapter 42

Castration

Castration is one of the most common surgical procedures performed on the horse. Horses may be castrated at any age, but the most common age is between 12 and 18 months. In temperate climates, castration in the early spring or late fall, when flies are not present, is desirable. Castration may be performed on the standing horse after sedation and administration of local anesthesia or after induction of short-acting general anesthesia. Numerous techniques are routinely used to successfully castrate horses.[1–3] All techniques have several principles in common: adequate restraint, safety, good anesthesia, clean surgery, control of hemorrhage, and adequate postoperative drainage. Veterinarians should be capable of castrating horses using several different methods, depending on the owner's preference, surgeon's preference, age of the horse, cooperation and tractability of the horse, testicular pathology, and reason for castration.

Routine castration is performed with an emasculator. This instrument crushes the spermatic cord to control hemorrhage and severs the cord distal to the crushed area. The most commonly used emasculator in North America is the White's improved emasculator.[a, 2] The Serra[b] and Reimer[c] emasculators are also popular.

[a]White's modified emasculator. Jorgensen Laboratories, Inc., Loveland, CO.

[b]Serra emasculator, Jorgensen Laboratories, Inc., Loveland, CO.

[c]Reimer emasculator, Jorgensen Laboratories, Inc., Loveland, CO.

Preoperative Procedures

The surgeon should always ensure that the correct animal is to be castrated and obtain a medical history. A brief physical examination to determine the health status of the horse is recommended. Castration is an elective procedure and should not be performed on a sick horse. The scrotum should be palpated to confirm the presence of both testes and to determine whether inguinal herniation is present. The horse may be tranquilized if necessary to complete external palpation for testes. If both testes are not found, the surgeon should be prepared for cryptorchidectomy or should not proceed. The tail should be wrapped so that the hair is folded into a short bun to prevent contamination of the surgical site in horses that are to be castrated while standing. The scrotum should be surgically prepared before local anesthesia and again before surgery. The surgeon should wear gloves for surgery and use sterilized instruments. Perioperative antibiotics are not considered necessary by many surgeons, and we do not use them routinely.[1] However, in one retrospective study of 23,229 castrations, horses receiving antibiotics had significantly fewer postoperative infections.[2]

Castration of the Standing Horse

Quiet stallions that allow palpation of the scrotum and testes with little resentment and without sedation are the best candidates for standing castration. Both testes must be present in the scrotum. Ponies, donkeys, mules, and horses with poorly developed testes are difficult to castrate standing. For standing castration, the horse should be restrained by a competent handler. A twitch is often helpful for restraint. We recommend sedation before surgery with xylazine hydrochloride,[d] detomidine hydrochloride,[e] or a combination of xylazine hydrochloride and butorphanol.[f] The surgeon and handler should work on the left side of the horse, and the surgeon should remain near the shoulder. For the right-handed surgeon, both testes are squeezed with the left hand into the bottom of the scrotum. Local anesthesia is achieved by using an 18-gauge, 1½-inch needle that is fully inserted into the center of the right testis, and 20 ml of mepivacaine hydrochloride[g] or lidocaine hydrochloride[h] is instilled. The needle is withdrawn so the tip is in a subcutaneous location, and 10 ml of anesthetic is instilled on a line 1 cm from the median raphe from the cranial to caudal pole of the testis (Fig. 42–1*A*). The left testis is anesthetized in the same manner. After anesthetic injection, the surgeon should wait 5 minutes for diffusion of the drug proximally into the spermatic cord.

Half-Closed Technique

Both testes are squeezed ventrally in the scrotum, and pole-to-pole parallel incisions are made through the skin and dartos over the testes 1 cm from the median raphe. The scalpel blade should be held with the fingers or wrapped in the aluminum foil package and not be put on a scalpel handle. Each incision is directed from cranial to caudal, away from the surgeon's left hand, which is positioning the testes in the bottom of the scrotum, to reduce chances of laceration of the surgeon's hands if the horse should kick (see Fig. 42–1*A*). The incision should be made over the right testis first. The testes, still contained within the common vaginal tunic, are freed from the scrotal fascia by forcing them ventrally and out of the incisions. Each testis is grasped and pulled downward with the left hand while the surgeon strips the fascia away from the testis and cord with the right hand. We prefer encircling the cord with the right thumb and index finger to make a tight ring and pushing upward (Fig. 42–1*B*). Alternatively, a gauze sponge can be used to assist stripping of the fascia from the tunic. Approximately 4 inches of cord should be freed from surrounding fascia. Holding each testis separately, the surgeon makes a 2-inch incision through the cranial aspect of the common vaginal tunic just above the testis. The thumb or index finger of the left hand is inserted into the cavity of the tunic, and the testis is prolapsed. The tunic will invert as the testis is prolapsed, and the flask-shaped distal end of the tunic that invested the testis will provide a pouch for the index finger (Fig. 42–1*C*). The testis is held in the palm of the left hand. Traction on the tunic will ensure adequate removal of these structures during emasculation. The tunic can be opened proximally 4 to 6 inches by sliding slightly opened scissors up the tunic (see Fig. 42–1*C*).

Next, the entire spermatic cord, tunic, and cremaster muscle can be emasculated in one step. The emasculator is positioned around the cord next to the testis and partially closed. The surgeon slides the emasculator up the spermatic cord proximally, being careful not to entrap scrotal skin, and positions it perpendicular to the cord so spermatic vessels are cut transversely. The surgeon should ensure that the crushing jaws of the emasculator are toward the horse and the cutting blades are toward the testis. Proper application occurs when the wing nut on the emasculator is closest to the testis. This is the so-called nut-to-nut position (Fig. 42–1*D*). Tension is released on the spermatic cord before it is severed. Stretched spermatic blood vessels may recoil as the emasculator is closed. Both hands are used to rapidly and firmly close the emasculator completely. The crush is maintained for 1 to 2 minutes and released by fully opening the jaws of the emasculator without putting tension on the crushed stump. The entire procedure is repeated on the second testis.

In mature horses with well-developed testes, the mesorchium is perforated to separate the vascular bundle of the spermatic cord from the ductus deferens, common tunic, and external cremaster muscle (Fig. 42–1*E*). To sever the ductus deferens, common tunic, and cremaster muscle, the emasculator is positioned around these structures as close to the scrotum as possible, ensuring adequate removal. The emasculator is closed rapidly and firmly, and the crush is maintained for 10 to 15 seconds. To sever the vascular cord, the emasculator is applied for 1 to 2 minutes.

Loose scrotal fascia, which hangs below the level of the scrotal incisions, should be removed with serrated scissors. Postoperative drainage is facilitated by stretching both incisions longitudinally to enlarge them. Alternatively, the median raphe may be removed with scissors.

[d]Rompun, Miles Inc., Shawnee Mission, KS.
[e]Dormosedan, Pfizer Inc., New York, NY.
[f]Torbugesic, Fort Dodge Laboratories, Inc., Fort Dodge, IA.
[g]Carbocaine V, The Upjohn Co., Kalamazoo, MI.
[h]Lidocaine 2% injectable, The Butler Co., Columbus, OH.

Figure 42–1.

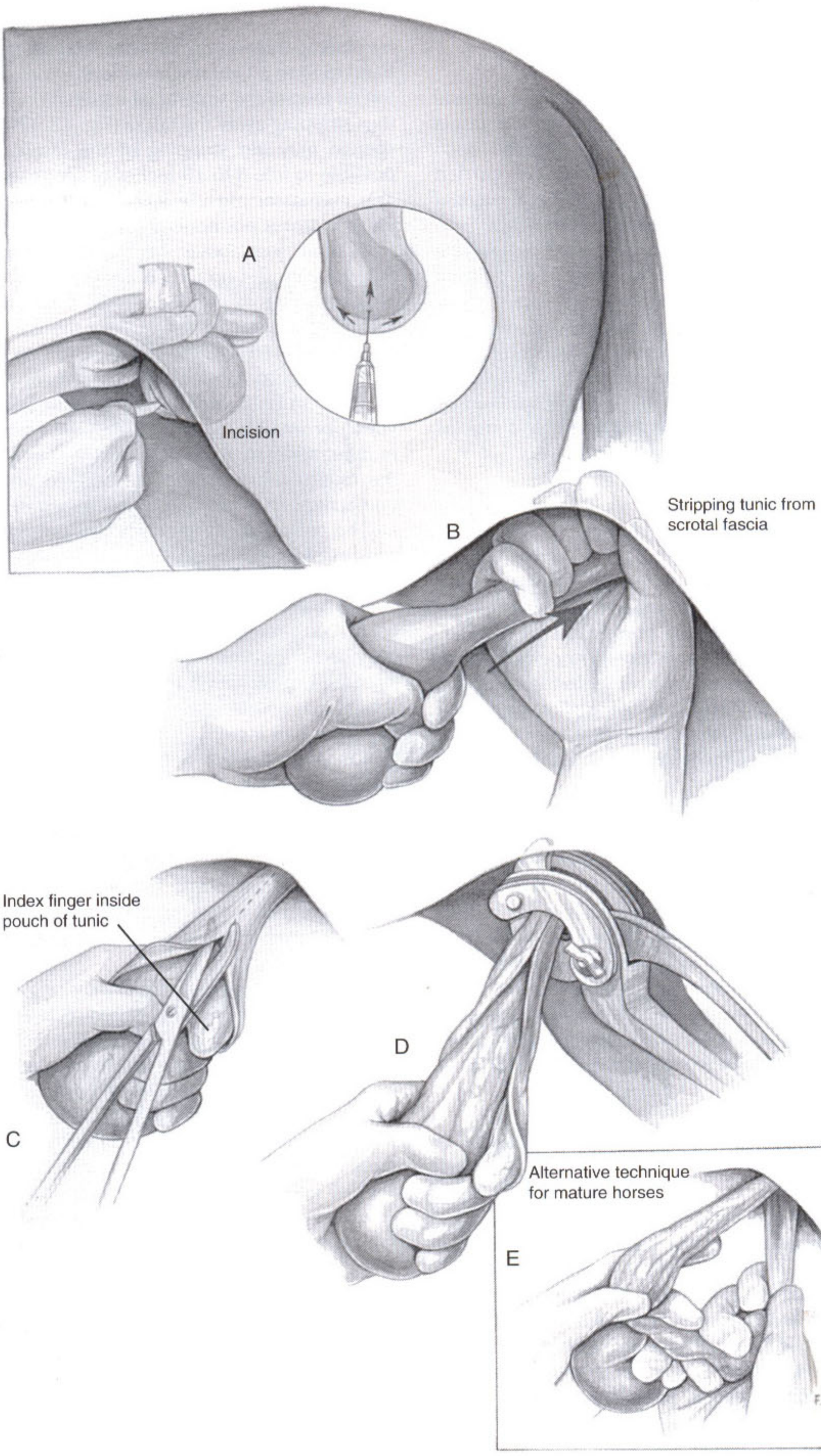


Illustration continued on page 213

Open Technique

Some surgeons prefer not to dissect the parietal (common) vaginal tunic free from the scrotal fascia during castration. To castrate horses using the open technique, the initial scrotal incisions are carried through the skin, tunica dartos, and parietal vaginal tunic. The testes immediately prolapse out of the incision. The tunics are left within the scrotum by severing the ligament of the tail of the epididymis at its point of attachment to the tunic. The mesorchium is perforated to isolate the testicular vessels and ductus deferens, and they are removed with emasculators. The open technique requires less dissection than the half-closed technique but has the disadvantage of leaving the entire tunic in the scrotum. This may increase the risk of hydrocele or scirrhous cord postoperatively.[1]

Castration of the Recumbent Horse

Many surgeons prefer to castrate horses using short-acting intravenous anesthesia. A clean, safe area to anesthetize and recover the horse must be located. The horse is sedated with xylazine hydrochloride[d] at 0.5 to 0.8 mg/kg IV. Ketamine hydrochloride,[i] 2.2 mg/kg, and butorphanol tartrate,[f] 0.044 mg/kg, are combined and given intravenously 5 minutes after the xylazine hydrochloride. The horse must be suitably sedated before this combination is administered, or anesthesia may be inadequate. The addition of butorphanol tartrate to the ketamine hydrochloride enhances muscular relaxation and analgesia and prolongs anesthesia for several minutes.[4] The horse is positioned in lateral recumbency with the upper hindlimb abducted or pulled forward with a rope that is tied around the neck (Fig. 42–1*F*). The right-handed surgeon operates with the horse in left lateral recumbency. Surgical preparation of the scrotum is performed expediently because anesthesia may last as little as 5 minutes. However, the duration of action of the anesthetic combination is usually 10 to 15 minutes.

Closed Technique

The surgeon puts on gloves and begins castration by forcing both testes into the bottom of the scrotum with the left hand. Parallel incisions 1 to 2 cm from the medium raphe are made through the skin and tunica dartos over each testis. The incisions should be at least 10 cm long (Fig. 42–1*G*). The testes within the intact parietal (common) vaginal tunics are squeezed through the ventral scrotal incisions. Each testis and tunic is grasped firmly and freed from surrounding scrotal fascia by placing traction on the testis and using the opposite hand to form a tight ring around the cord, which is then forced toward the superficial inguinal rings of the horse, thus stripping away the fascia (Fig. 42–1*H*). A dry gauze sponge may aid stripping of the fascia. It is usually possible to free 8 to 10 inches of spermatic cord, tunic, and cremaster muscle from surrounding fascia. The emasculator is positioned "nut to nut" around the common tunic just above the testis and partially closed before being slid up the cord to the level of the scrotal incisions (Fig. 42–1*I*). Care should be taken to avoid incorporating skin in the jaws of the emasculator. The testis is released so there is no traction on the cord, and the emasculator is closed perpendicular to the cord in a rapid, smooth motion using both hands. Even in young or small horses, closure of the emasculators will require moderate force because the spermatic cord and the musculofibrous cord are severed and crushed in one action. This method of closed castration can generally be performed easily on horses up to 24 months of age. In older stallions with thick cords, the cremaster muscle may be separated from the vaginal tunic and emasculated separately, or a transfixation ligature may be placed around the cord. The scrotal incisions are stretched or enlarged to ensure adequate drainage.

All horses with a history of scrotal swelling, with an inguinal hernia as a foal, or with siblings or relatives that have had inguinal hernias or eventration after castration should have a transfixation ligature placed around the entire spermatic cord and common tunic before emasculation. The ligature is placed above the level of emasculation using size 1 or 2 polydioxanone suture material.[j] The ligature will reduce the risk of hemorrhage from the testicular vessels and the risk of postoperative eventration of viscera. The ligature may, however, increase the risk of postoperative infection.[2, 3]

Primary closure of scrotal incisions after castration has been recommended to hasten recovery by decreasing drainage, edema, and infection in the postoperative period.[1, 5] Primary closure increases surgical time, and strict adherence to aseptic technique is required to prevent incision infections.[1] After closed castration, primary closure begins by ablation of the scrotum. Dead space can be eliminated by subcutaneous sutures using size 2–0 polydioxanone[j] material.[5] Skin is apposed with a continuous subcuticular pattern using size 2–0 or 3–0 polydioxanone[j] suture material.

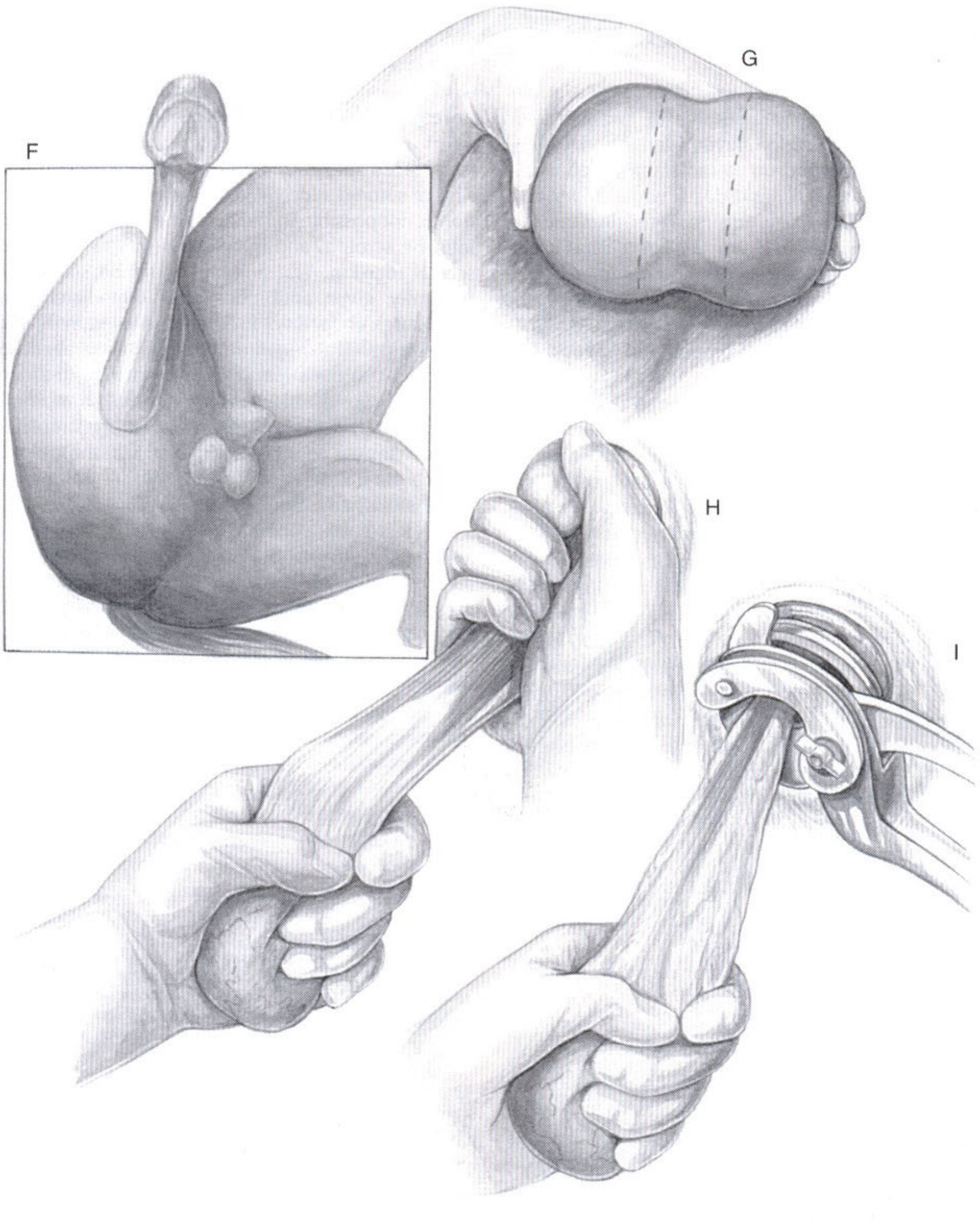
Postoperative Management

After castration, horses should be confined and observed for 24 hours, after which they are exercised for 30 minutes twice daily to promote wound drainage. When skin incisions close prematurely, they should be

[i]Ketaset, Fort Dodge Laboratories, Inc., Fort Dodge, IA.

[j]PDS II, Ethicon, Inc., Somerville, NJ.

Figure 42–1. *Continued*



opened with a gloved finger. Poor drainage will increase postoperative swelling of the prepuce, sheath, and penis. In the absence of complications, full work can resume in 7 to 10 days. The vaccination status of the horse should be determined and tetanus prophylaxis provided when needed.

Complications associated with castrations are frequent and include inadequate anesthesia, swelling and edema, hemorrhage, infection, fever, eventration, lameness, hydrocele formation, unaltered stallion behavior, peritonitis, penile paralysis, and death while under anesthesia.[1–3, 6] In one survey equine veterinarians reported 8747 complications from 23,229 castrations.[2] Excessive edema was the most common complication.[2] The closed castration technique was associated with the lowest occurrence of excessive hemorrhage, edema, and infection, compared with the open and half-closed techniques.[2]

Excessive hemorrhage can be caused by bleeding from scrotal veins or the testicular artery. Most bleeding from scrotal veins will stop spontaneously or after packing of the scrotum. Large veins that are inadvertently severed or torn should be identified and ligated. Uncontrolled bleeding from the testicular artery can result in death. Excessive hemorrhage can be prevented by avoiding placing skin in the emasculator jaws; leaving the emasculators on the cord for 1 to 2 minutes; not using emasculators that are poorly adjusted; ligating the spermatic cord in older horses; and avoiding traction on the cord during emasculation. Profuse hemorrhage from the artery is best managed by identifying and ligating the artery. An angle clamp such as a Mixter curved kidney clamp[k] or Satinsky vessel clamp[l] is useful to reach into the inguinal canal and grasp the stump of the spermatic cord. A curved Carmalt forceps may also be used. Horses castrated while standing may have to be anesthetized for locating the artery. We believe that packing the scrotum to control arterial bleeding is risky because hemorrhage may continue and can flow into the abdomen, where it is undetected.

Eventration of small intestine or omentum usually occurs within 4 hours of surgery but can occur as late as 6 days.[6] This complication is infrequent, with 47 reported eventrations in 23,229 castrations.[2] Small intestinal prolapse through the inguinal canal is life threatening and needs to be handled immediately.[2, 3, 6] Prolapsed small intestine should be lavaged and replaced into the abdominal cavity through the inguinal canal. The horse should be anesthetized and positioned in dorsal recumbency for this procedure. Before induction of general anesthesia, prolapsed bowel should be supported with a clean towel held against the groin or with a support sling to prevent further damage to exposed bowel. To replace the prolapsed bowel, the vaginal ring may need to be dilated or incised. After bowel is replaced into the abdomen, the superficial inguinal ring is sutured closed. When management of eventration is not possible in the field, the bowel can be placed into the scrotum and maintained there by suturing the scrotal incision. The animal should be stabilized systemically, given antibiotics, and immediately referred to a surgical facility. Prolapsed omentum is not life threatening. The omentum should be lavaged and ligated next to the superficial inguinal ring, the exposed omentum transected, and the proximal stump replaced in the abdomen.[6] Veterinarians must be completely familiar with all possible complications, the methods to reduce the incidence of complications, and methods of treatment when complications occur.[1, 3]

Horses that continue to show objectionable sexual and aggressive behavior have been termed "proud cut," and the lack of behavioral modification has been blamed on poor technique by the veterinarian. This is rarely if ever the case. Up to 30% of colts castrated before puberty continue to display stallion-like sexual behavior and aggression toward other horses, and about 5% are aggressive toward people.[7] Owners should be informed before castration that objectionable behavior will not be eliminated in all horses.

[k]Mixter forceps, 11-inch, right-angle jaws, Miltex Instrument Company, Inc., Bethpage, NY.

[l]Satinsky vascular clamp, Miltex Instrument Company, Inc., Bethpage, NY.

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chapter 43

Noninvasive Inguinal Cryptorchidectomy

Cryptorchidism is the most common nonlethal congenital defect in the horse. It is the failure of one testis or both testes to descend into the scrotum. The testes may be in the abdominal cavity or in the inguinal canal ("high flanker"). Occasionally, the tail of the epididymis or a loop of ductus deferens will descend into the inguinal canal, and the testis will remain in the abdomen. Such horses are "partial" abdominal cryptorchids, and the epididymis can be confused with a normal testis or with inguinal cryptorchidism. The incidences of left and right cryptorchid testes are approximately equal. Seventy-five percent of left retained testes are abdominal, and 42% of right retained testes are abdominal. Bilateral cryptorchidism occurs in 14% of horses with cryptorchidism; bilaterally abdominal testes occur in 8%.[1]

The cause of cryptorchidism is unknown. However, heredity is believed to be involved. One study implicates both sire and dam.[2] The survey of one dam and her progeny involving several bloodlines suggests a polygenetic trait with some dominance.[2] The high incidence of cryptorchidism in certain breeds of horses substantiates the impression that heredity is a causative factor.

Fifty percent of all foals have descended testes at birth. Palpation of the scrotum of newborn foals is not reliable for determining testicular descent because the gubernacular bulb feels like a testis for up to 3 weeks. The left testis frequently lags behind the right testis in descent by a distance of as much as 6 cm. Because the vaginal ring contracts to approximately 1 cm in diameter during the first 2 weeks after birth, the left testis is more likely to be "trapped" in the abdominal cavity. An abdominally retained testis is unlikely to descend into the inguinal canal after 3 to 4 weeks of age. Descended testes are unlikely to permanently return to the abdomen. Of course, further descent of inguinal testes, particularly right testes, into the scrotum may occur as the horse ages, but even this appears to be unlikely after 2 years. There is no evidence that removing one normal testis will enhance the descent of the other retained testis. Rather, removal of a scrotal testis may result in marked hypertrophy of a remaining abdominal testis.[3]

The complete history of the horse, including previous surgery, should be ascertained. If the position of the retained testis or testes is determined preoperatively, the noninvasive inguinal approach to surgery is facilitated. External palpation of the inguinal rings and rectal palpation are helpful. Chemical sedation and proper restraint are used as needed. Rectal palpation establishes the size and presence of the vaginal rings and the absence or presence of the ductus deferens passing through the vaginal rings. A small vaginal ring (<1 cm or indiscernible) without a ductus deferens is consistent with an abdominally retained testis. A larger ring (up to 2 cm) with a ductus deferens passing through the caudomedial aspect indicates a normal scrotal testis, an inguinal cryptorchid, or a partial abdominal cryptorchid. Approximately 10% of the cryptorchids with the ductus deferens passing through the vaginal ring will be partial abdominal cryptorchids.

The ductus deferens is a small (up to 3 mm) tubular structure that can be difficult to identify by rectal examination, particularly if the horse is uncooperative. The ductus can be "tensed" on its mesodeferens (fold of mesorchium) by stroking the parietal peritoneum in the region of the vaginal ring with the index finger. The tensed ductus can be felt to slip under the finger like a strand of wet spaghetti. The pudendal vessels are retroperitoneal in the same location and can be confused with the ductus deferens. The vessels are slightly larger, softer, and shorter and are not movable like the ductus. Abdominal testes are small, soft, and difficult to distinguish from intestine. Large teratomatous or cystic testes are rare and are frequently out of reach.

Horses with one testis previously removed and geldings with stallion-like behavior present unique diagnostic problems. Examination of the scrotal area for a castration scar requires anesthesia and dorsal recumbency. The common practice of removing the median raphe with a resultant median scar negates the value of

this examination in such cases. Plasma testosterone levels, with or without human chorionic gonadotropin stimulation, have been helpful when evaluating horses previously operated on.[4] Testosterone levels below 25 pg/ml are consistent with gelding status; levels above 100 pg/ml are consistent with stallion/cryptorchid status.

Anesthesia, Positioning, and Surgical Preparation

Cryptorchidectomy is abdominal surgery that mandates general anesthesia, dorsal recumbency, and aseptic technique. Depending on the experience of the surgeon, intravenous or inhalation anesthesia is acceptable. Except for known high flankers, we use inhalation anesthesia and full draping in the teaching hospital because students and residents assist with the procedure.

Surgery

The retained testis is found and removed first. A 12- to 14-cm incision is made directly over the superficial inguinal ring (Fig. 43–1*A*). The canal is entered by blunt dissection of the loose, "smooth" fascia without creating hemorrhage. Care should be taken to avoid tearing inguinal vessels. Identification of genital structures requires visualization as well as palpation; misdirection of the dissection laterally into the thigh fascia or hemorrhage from large scrotal or pudendal veins will complicate the procedure from the outset. For inguinal cryptorchids, the testis within the tunic is easily exposed. Routine castration follows, and such cases can be managed on an outpatient basis. In the event of a partial abdominal cryptorchid, the ductus deferens or epididymis is identified and the testicle exteriorized with gentle traction and removed. Care must be taken not to remove the tail of the epididymis alone, believing it to represent the testis.[5]

When the testis or epididymis is not in the canal, dissection is carried to the deep inguinal ring. An everted vaginal process or a prominent inguinal extension of the gubernaculum can be palpated and seen as white-gray mesothelial structures (Fig. 43–1*B*). An inverted vaginal process can be palpated as a peritoneal cul-de-sac at the deep ring. A 25-cm curved sponge forceps is placed in the cul-de-sac to grasp the vaginal process and evert it into the inguinal canal (Fig. 43–1*C*). Gentle traction will tear the vaginal process, exposing the epididymal ligament and epididymis. If the vaginal process is thick and fibrous, it can be nicked or incised with Metzenbaum scissors. Steady, firm traction on the epididymis and its ligament will produce the testis. It can be felt to bulge against the vaginal ring as the peritoneum stretches during exteriorization (Fig. 43–1*D*). Occasionally the vaginal ring will need to be gently stretched or torn to allow passage of a large testicle. The testicle, epididymis, and convoluted portion of the ductus deferens can be removed by emasculation, by ligation and division, or with an écraseur.[a] Failure of this approach requires invasion of the abdomen.

Paramedian or parainguinal laparotomy can be performed while the horse is under anesthesia if the noninvasive technique fails or if a teratoma or large cystic testis is present.[6] Except for the time and increased postoperative morbidity, laparotomy is a safe, standard procedure. In addition to teratomas or cysts, which are uncommon, the surgeon must be prepared for one other eventuality. Monorchidism, or the complete absence of a testis on one side, has been reported.[7, 8] However, this is extremely rare, and in most circumstances it is the failure of the surgeon to find both testes. Postoperative plasma testosterone levels can be used to prove monorchidism when only one testis has been identified and removed.

The method of closure is dependent on the degree of invasiveness. Because the defect at the vaginal ring may be small, similar to castration of a normal horse, no closure may be necessary. As a holdover from the days of invasive surgery, we have packed the inguinal canals with sterile gauze and sutured the skin. A layered closure with primary healing is also practiced. Most recently, we have performed a scrotal ablation and primary closure in horses that have not been previously operated on.[9] In the event of a paramedian laparotomy, complete suture closure is required; simple interrupted sutures of size 2 polydioxanone[b] are used in the external rectus fascia. Subcutaneous tissues and skin are closed routinely.

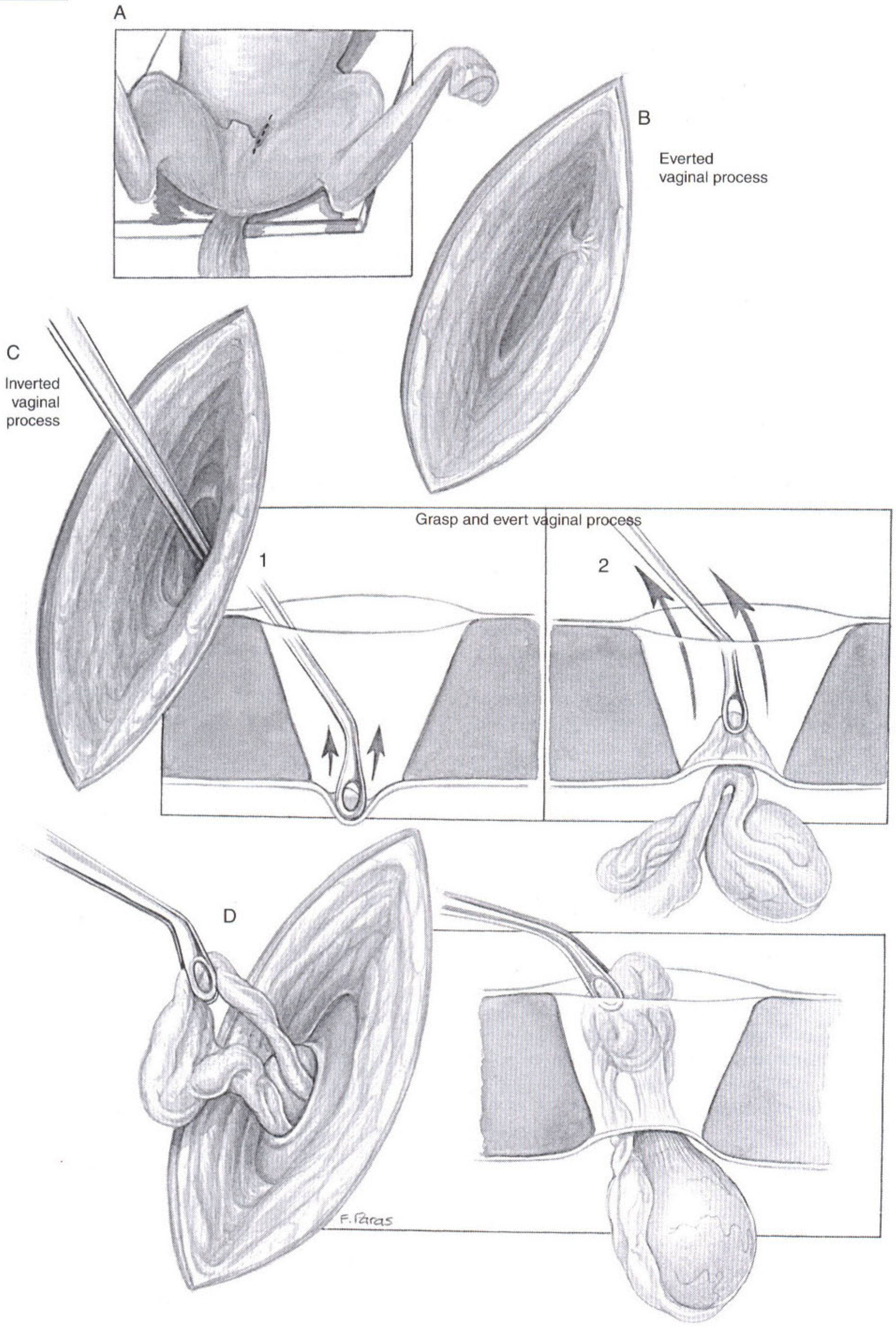
In the future, laparoscopic approaches may supplant standard surgical procedures for many abdominal approaches in the horse, but currently the noninvasive cryptorchidectomy is safe, less expensive, and less time-consuming than laparoscopic cryptorchidectomy.[10]

Postoperative Management

Histopathology should be used to document proper removal of the cryptorchid testicle and to substantiate suspected cases of monorchidism or tumors. If the inguinal canal has been packed, 24 hours after surgery a rectal examination is performed to exclude adhesions or herniation, and the skin sutures and gauze packing are removed. The horse is discharged from the hospital immediately thereafter and exercised as recommended for a standard castration. Tetanus prophylaxis is provided. Antibiotics are not used.

[a]Écraseur, Jorgensen Laboratories, Inc., Loveland, CO.
[b]PDS II, Ethicon, Inc., Somerville, NJ.

Figure 43–1.


A
B
Everted
vaginal process
C
Inverted
vaginal
process
Grasp and evert vaginal process
1
2
D
F. Paras

References

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chapter 44

Neonatal Inguinal Herniorrhaphy

Newborn colts can acquire inguinal hernias at the time of birth or within several days of birth. Hernias probably are related to trauma, straining, and large vaginal rings. The abdominal pressure associated with the expulsive second stage of labor in the mare may displace small intestines into the inguinal canal or scrotum as the foal's trunk passes through the birth canal. The straining of foals to pass meconium may be another cause. Testicles can descend into the scrotum anytime during the first several weeks of life because the vaginal rings are large. The absolute cause of these hernias is uncertain, but because they are congenital defects and may have a hereditary predisposition, it is generally agreed that surgical correction should include castration.

Most congenital inguinal hernias are indirect hernias, with the intestines passing through an intact vaginal ring and contained within the parietal layer of the vaginal tunic.[1] Foals present with unilateral or bilateral soft, nontender enlargements in the inguinal-scrotal region. Usually, the hernias are reducible, are not a cause of colic, are not life threatening, and resolve spontaneously within several days. Some hernias will resolve after several months of life. In the absence of signs of colic or other suggestion of intestinal dysfunction, handlers can reduce the hernia as frequently as necessary until the vaginal rings close down and the hernia resolves. A medical record of these colts should be maintained because the incidence of evisceration after castration may be higher than occurs in normal colts. Transfixation ligation of the spermatic cord should be used when castrating colts with a history of inguinal herniation.

Occasionally, the parietal vaginal tunic or the peritoneum in the vaginal ring region tears, and the intestines become positioned against the dartos and subcutaneous tissues of the scrotum. Such ruptures are irreducible, can be very large, and may be an imminent threat to life.[1, 2] In the absence of a peritoneal sac, it may be possible to visualize the individual loops of intestine under the skin. The inguinal skin is thin and delicate in foals, and the stretching can disrupt dermal circulation that leads to sloughing.

Anesthesia, Positioning, and Surgical Preparation

The reducible hernia that fails to resolve within several days or weeks can be managed surgically on an elective basis. Large, irreducible hernias, including inguinal ruptures, mandate emergency surgical intervention before intestinal compromise develops. Ninety percent of foals presented to veterinary teaching hospitals for inguinal hernias are treated surgically.[2] Because most of these colts are not systemically ill, continuous intravenous drip anesthesia or inhalation anesthesia may be satisfactory, depending on the practice arrangements and the preference of the surgeon. Because ventral midline laparotomy may be necessary to completely assess the status of the intestines, we prefer inhalation anesthesia, which provides greater safety and flexibility of operative time.

The foal is positioned in dorsal recumbency, and the inguinal region and ventral midline are routinely prepared for aseptic surgery. Because of the tender, thin inguinal skin, hair is carefully clipped and shaving is avoided. The surgical scrub is performed with a wiping action, compared with vigorous scouring, and the surgical soap is rinsed with sterile saline solution. No alcohol or harsh chemical is used. Most of these cases do not entail intestinal resection, but perioperative antibiotics are used, being administered just before anesthetic induction, in the event such resection leads to a clean-contaminated status for the surgery. Replacement of intestine into the abdominal cavity may be accompanied by the potential release of endotoxin and vasoactive substances sequestered in the herniated bowel. These foals should receive a nonsteroidal anti-inflammatory drug or antihistamine preoperatively to counteract the adverse cardiovascular effects of such substances. We use a single preoperative dose of flunixin meglumine,[a] 1.1 mg/kg IV.

[a]Banamine solution, Schering-Plough Animal Health Corp., Kenilworth, NJ.

Surgery

To replace intestines into the abdominal cavity and to secure the inguinal canal against recurrence of the hernia, good exposure is essential. A liberal skin incision is made over the inguinal swelling, extending from the rostral margin of the superficial inguinal ring caudally to include the scrotum (Fig. 44–1*A*). In the case of inguinal rupture, intestinal loops are directly under the skin. A combination of blunt and sharp dissection is used to identify and free the testicle and vaginal tunic. For indirect hernias, the tunics are twisted under tension in order to "milk" the intestines back into the abdomen (Fig. 44–1*B*). With the twist maintained, a transfixation ligature of size 1 polydioxanone[b] is placed in the tunics within the inguinal canal (Fig. 44–1*C*). The testicle and redundant tunics are emasculated distal to the ligature. The transfixed stump of tunics can be incorporated in the ring closure. For ruptures, the tear in the parietal vaginal tunic is identified, and the intestines are replaced into the abdominal cavity. "Last out, first in" is the rule of thumb for finger-feeding the loops back through the inguinal canal. This requires patience and, if the intestine is markedly congested and edematous, enlargement of the vaginal ring. After the intestines are replaced, the tunics and testicle are emasculated.

The superficial inguinal ring is closed with simple interrupted sutures of size 1 polydioxanone[b] (Fig. 44–1*D*). Suture of the superficial inguinal ring in foals is more straightforward than in adult horses, but preplacement of sutures to equalize tension is advised. Sutures should be placed at varying distances from the edges of the ring to avoid all of the tension in one fascial plane. Depending on the vitality of the skin, both primary closure of the subcutaneous tissue and skin, with or without a drain, and leaving the wound open are suitable options. The surgeon should aim for primary healing, but it may be futile if the skin has lost its dermal blood supply. Such devitalized skin can be sutured over the deeper tissues as a temporary biologic bandage, but drainage should be provided. Standard castration is performed on the opposite side.

Most of these cases involve herniation of jejunum, which, depending on the duration of incarceration, does not require resection and anastomosis. However, if the integrity of the bowel is in doubt, the manipulation required to replace the loops has been extensive, or the patient demonstrates cardiorespiratory changes suggestive of devitalized intestinal mucosa (e.g., a bout of hypotension as the intestines are replaced), the surgeon should proceed with a midline exploratory laparotomy during the same anesthetic period (see Chapter 16). The laparotomy allows careful inspection of the bowel to determine bowel integrity, gives the best exposure for bowel resection and anastomosis when necessary, and provides the opportunity to resect umbilical remnants in neonates.

[b]PDS II, Ethicon, Inc., Somerville, NJ.

Postoperative Management

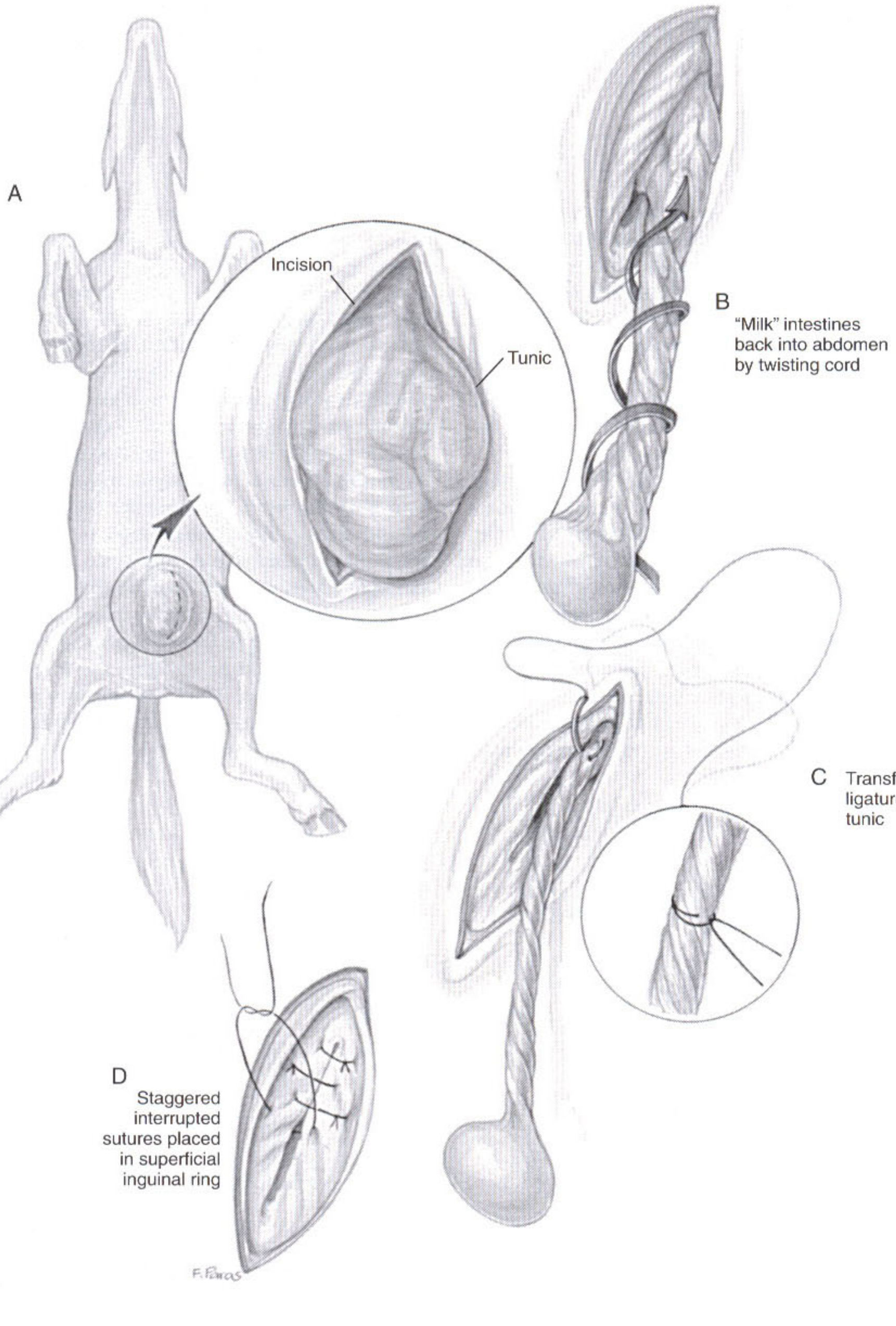
Newborn foals must be monitored regularly for suitable colostrum ingestion and septicemia developing from other causes. Because most of these foals are not systemically ill, medical management is not extensive. Antibiotic and nonsteroidal anti-inflammatory drug administrations are limited to the day of surgery unless indicated for other medical reasons. Edema of the incision site and prepuce may be extensive but is harmless in the absence of extensive cellulitis. If drains are used, they should be removed by the second postoperative day. Drainage from open incisions can scald the skin between the legs; petroleum jelly can be used to coat and protect the skin in such cases.

The major complication with inguinal herniorrhaphy is the failure to resect devitalized bowel.[1] This judgment error can be avoided by exploratory laparotomy. All equine neonates are vulnerable to septicemia; the resection of umbilical remnants as a part of exploratory laparotomy can be preventive. Other complications such as incisional infection or wound dehiscence with evisceration are, fortunately, uncommon in these patients but reflect technical problems with the surgery when they occur.

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Figure 44–1.


A
Incision
Tunic
B
"Milk" intestines back into abdomen by twisting cord
C
Transfixation ligature through tunic
D
Staggered interrupted sutures placed in superficial inguinal ring

chapter 45

Penile Amputation

Neoplasia, specifically squamous cell carcinoma, is the most frequent indication for amputation of the equine penis. This cancer is characterized by cauliflower-like ulcerated growths with a foul smell and secondary infection, and it must be differentiated from benign lesions such as habronemiasis that can be treated conservatively. The glans penis is the most common site for tumor development.[1] When the carcinoma has invaded the deeper tissues or urethra and is no longer amenable to topical treatment with cytotoxic drugs[2] or local excision, amputation is the treatment of choice. Because aged geldings are often affected and the tumor may have been present for a long period before detection, a complete physical examination for metastases must be conducted. The superficial inguinal lymph nodes can be expected to be prominent and readily palpable because of the secondary inflammation and infection that accompany squamous cell carcinoma, but large solid masses in the prepuce or superficial inguinal ring regions may be metastases. Fine-needle aspiration and cytology may be helpful in identifying regional lymph node metastases that would detract prognostically from the surgical outcome. Rectal palpation should be performed before penile amputation. Some metastases in the deep inguinal or iliac lymph nodes may go undetected by rectal palpation, but obvious masses in the pelvic or caudal abdominal cavities signal a poor long-term prognosis for the patient. Cytology of abdominal fluid may help to confirm the spread of cancer in such cases.

Amputation of the penis for causes other than squamous cell carcinoma should be considered a last resort. Refractory paraphimosis, particularly when complicated by trauma or frostbite, may be treated by amputation when the Bolz procedure for permanent penile retraction would be unsuitable.[3] Paraphimosis from other causes (e.g., after priapism in stallions, the use of phenothiazine tranquilizers, or general anesthesia) should be treated medically or managed by the Bolz technique before secondary problems develop. Stallions should be castrated before either the Bolz procedure or penile amputation is performed.

Anesthesia, Positioning, and Surgical Preparation

For aged horses, carefully monitored inhalation anesthesia is the safest anesthesia. The horse is positioned in dorsal recumbency, and the penis, prepuce, and inguinal region are prepared for aseptic surgery. The hair is clipped from the prepuce and ventral abdomen in the region where the penis is extended. All smegma and surface debris must be removed by vigorous washing. If possible, the bladder is catheterized with a 28 to 32 French stallion urinary catheter,[a] and the glans penis is snared with umbilical tape, which is towel-clamped to the abdominal skin, holding the penis in extension (Fig. 45–1*A*). A rubber tourniquet is placed as proximal as possible on the penis before the final surgical scrub and draping. The diseased glans should be isolated from the surgical field with drapes. This may be impossible for large, extensive lesions. A perioperative antibiotic that establishes high urinary concentrations is administered as an intravenous bolus just before anesthetic induction. Penicillin G potassium,[b] 22,000 U/kg, is suitable.

[a]Stallion urinary catheter, Jorgensen Laboratories, Inc., Loveland, CO.

[b]Penicillin G potassium, Bristol-Myers Squibb Co., Princeton, NJ.

Surgery

Amputation is commonly performed between the preputial ring and the preputial orifice. A 5- to 6-cm-long triangular piece of skin with a 3-cm base facing the glans is resected from the ventral surface of the penis (see Fig. 45–1*A*). This triangulation reduces the amount of redundant skin and may help prevent urethral stricture as a postoperative complication.[3] A ventral midline longitudinal incision, centered in the triangle, is continued between the retractor penis muscles and through the bulbospongiosus muscle, the corpus spongiosum penis, and the urethral mucosa to expose the catheter (Fig. 45–1*B*). Simple interrupted sutures of size 2–0 polydioxanone[c] are used to approximate the urethral mucosa to the skin on the two long sides of the triangle (Fig. 45–1*C*). These sutures must be small and close to compress the corpus spongiosum penis, which becomes engorged during micturition, and to foster early mucosa-to-skin healing. After this urethral spatulation has been created, a short margin of distal urethral mucosa is preserved for final closure of the stump.

[c]PDS II, Ethicon, Inc., Somerville NJ.

Figure 45–1.

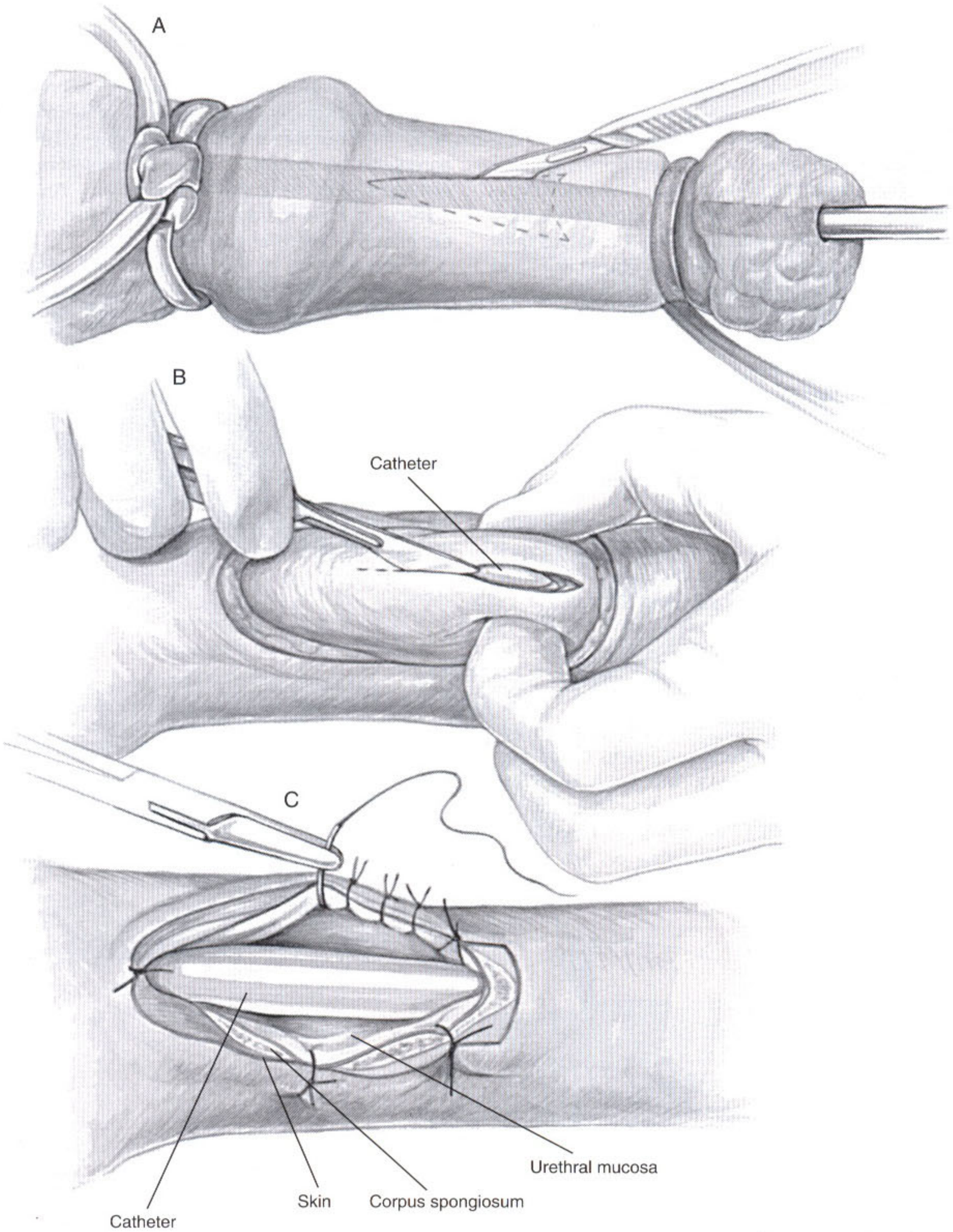


Illustration continued on page 227

The redundant skin, dorsal vessels, and body of the penis are transected by incising in a dorsal and cranial inclination (Fig. 45–1*D* and *E*). This should create a penile stump slightly longer than the spatulated urethra, helping to divert urine downward in the standing horse.[3] The arteries and veins that surround the penile stump are easily identified, even with the tourniquet in place (see Fig. 45–1*D*). Each vessel must be individually ligated to ensure complete hemostasis. The borders of tunica albuginea are sutured dorsoventrally, using simple interrupted sutures of size 1 or 2 polydioxanone (Fig. 45–1*F*). The first suture bridges the center of the stump. Subsequent sutures bisect the halves until the tunica is apposed. This tunica is fibroelastic and apposes well, effectively sealing the sinusoidal spaces of the corpus cavernosum penis. This seal is the most important insurance against massive blood loss. When vessels have been ligated and the corpus cavernosum penis has been sealed, the tourniquet is loosened. All hemorrhage is controlled before skin closure. The skin and preserved margin of urethral mucosa are tailored and sutured in a routine manner with size 2–0 polydioxanone (see Fig. 45–1*F*). Sutures should be closely spaced to compress the corpus spongiosum. This synthetic monofilament delayed-absorbable suture is strong and nonirritating and precludes the need for suture removal. Some skin redundancy is unavoidable.

Postoperative Management

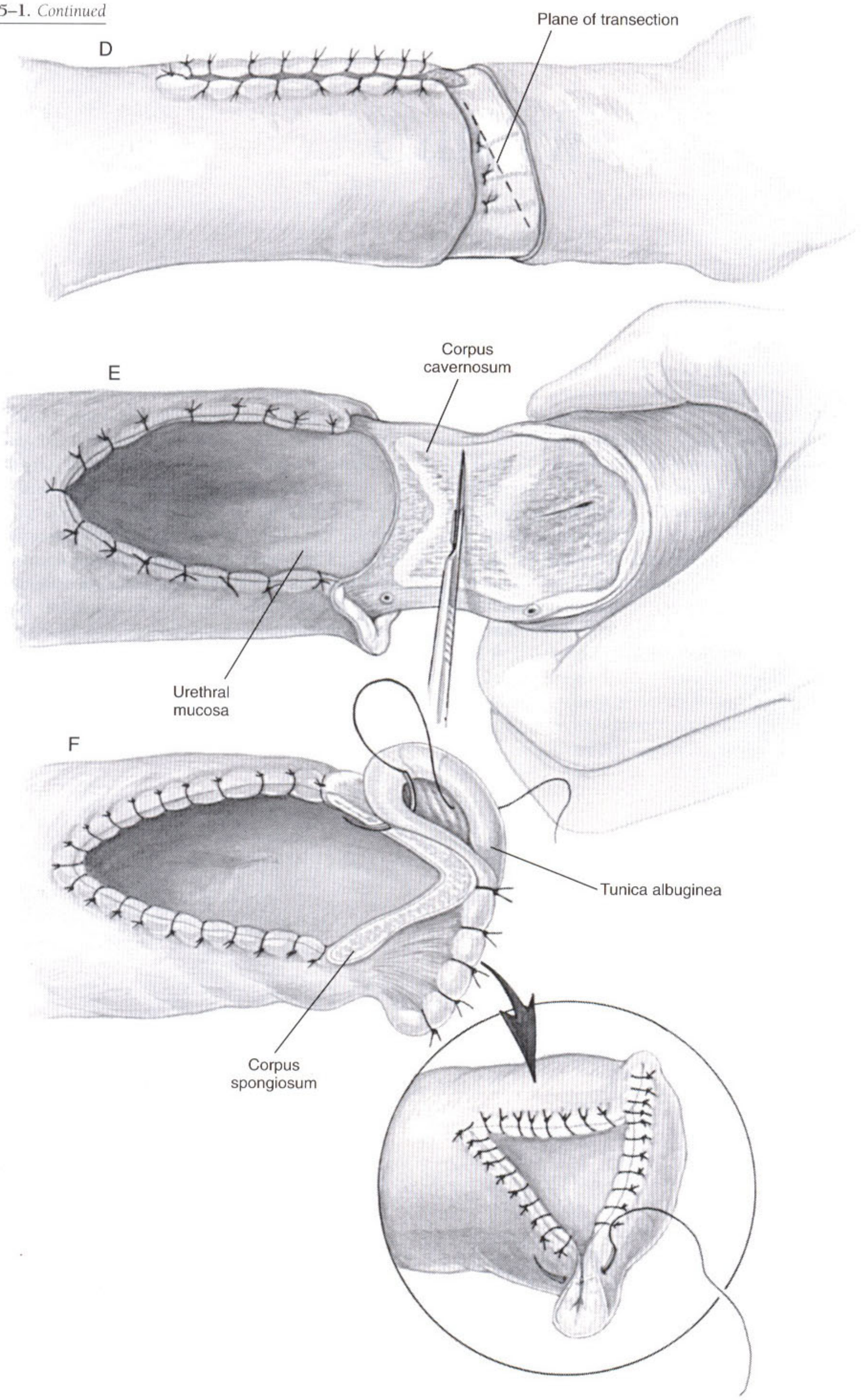
Slight swelling of the prepuce and minor hemorrhage accompanying the urethral pulsations of micturition are common after surgery, but such bleeding should not persist beyond 2 or 3 days. These horses tend to dribble urine and blood on their hind limbs until the swelling subsides and healing occurs. Minor dehiscence of the spatulated urethra with granulation tissue formation is not uncommon and can heal without consequence. However, persistent bleeding, particularly dissecting hemorrhage in the tissues, can lead to suture dehiscence and granulation of the stump, which requires reoperation. Urethral stricture may follow neglected dehiscence or repeated surgery. Most horses undergoing penile amputation do not require extended antibiotic therapy. Nonsteroidal anti-inflammatory drugs are beneficial for 3 to 5 days. The value of parenteral hemostatics is questionable; persistent hemorrhage should be controlled surgically. An indwelling catheter can be maintained for several days to reduce the effects of urethral pulsations.

Recurrences of the neoplasm and metastases are the most serious complications accompanying penile amputation. More than 10% of these squamous cell carcinoma cases have metastatic disease of the local lymph nodes at the initial examination.[1] More than 60% of those with glans penis involvement survive for 18 months or longer; if the urethra is involved, survival for 18 months or more drops to 30%.[1] We have experienced rapid, disappointing spread of squamous cell carcinoma within weeks of surgery and with metastases to the lungs. Owners must realize that penile amputation as a treatment for squamous cell carcinoma may not be a cure.

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Figure 45–1. *Continued*



chapter 46

Caslick's Procedure

Vulvoplasty, best known as the Caslick's procedure, is most commonly indicated and used as a treatment for pneumovagina in mares. Aspiration of air and fecal material into the vestibule and vagina results in endometritis and infertility in broodmares and objectionable noise in race and show mares. Abnormal conformational changes of the perineal region can accompany multiple pregnancies, aging, loss of physical condition, and injuries such as perineal lacerations. A lack of tone and scarring in the vulvar, vestibular, or vaginal suspensory structures compromise the normal seal these structures provide to the deeper genital tract. When the perineum sinks into the pelvis and the anus is cranial to the vulva, which is tipped forward, fecal contamination of the genital tract is inevitable. Vulvoplasty increases the conception rate in such mares,[1] serves as the second- or third-stage surgery in the repair of perineal lacerations (see Chapter 49), and is done at the owner's or trainer's request in show mares and race fillies.

Anesthesia, Positioning, and Surgical Preparation

Stocks, a dutch door, or straw bales are used to position the standing mare and provide protection for the surgeon. A twitch and chemical restraint are used when indicated. The tail is wrapped and tied out of the field. Clipping of hair from the perineal region is unnecessary. The vulva, caudal vestibule, anus, and surrounding perineum are washed with surgical soap and rinsed with water. No strong disinfectants are used. The lips of the vulva are infiltrated with a local anesthetic at the mucocutaneous junction. A 22-gauge, 1½-inch needle is used to create a prominent bleb that demarcates the extent of the intended vulvoplasty (Fig. 46–1*A*). If anesthetic is injected ahead of the needle as the bleb is created, the mare is less disturbed by the process. One surgical scrub is repeated after the infiltration. Drapes are unnecessary, but the surgeon should don sterile gloves and use autoclaved or cold-sterilized instruments.

Surgery

The intent of the surgery is to create healing of the vulvar lips together to form a seal. Fifty percent or more of the vulvar cleft is closed, extending from the dorsal commissure ventrally to the pelvic brim or slightly below. Using sharp scissors, a 4-mm strip of the infiltrated mucocutaneous margin is excised (Fig. 46–1*B*). More mucosa than skin should be excised. For broodmares that sustain repeated vulvoplasty, a minimum of fresh tissue should be removed each time, but a too-narrow or too-shallow excision results in healing failures. It is important to include the dorsal commissure of the vulva with the excision to avoid a leak at the top (Fig. 46–1*C*). An alternative to excising a strip of tissue is to incise the mucocutaneous junction with a scalpel and remove a 2- to 3-mm border of mucosa.[2] The defect is closed with a suture pattern and material of the surgeon's choice. We prefer a size 2–0 monofilament synthetic nonabsorbable suture[a] placed in an interrupted vertical mattress pattern (Fig. 46–1*D*). It is important to approximate the mucosal and cutaneous margins of the defect to ensure a good seal; the vertical mattress pattern augments this mucosal and skin apposition, compared with other suture patterns that appose only the skin.

Postoperative Management

Except for suture removal at 10 to 12 days and opening the vulvoplasty for natural breeding and foaling, no aftercare is required. Topical antibiotic application is not needed. Ointments should be avoided because they collect feces and dirt at the site. Tetanus immunization should be considered if the immunization status of the mare is unknown. Suture removal is neglected in many management situations, and this is undesirable. When sutures are left in place after 14 days, epithelial migration into the subcutaneous tissues occurs along the suture tracks, creating a foreign body reaction. This reaction, combined with fecal contamination of the exposed sutures, can lead to failure of the operation. However, the use of a monofilament synthetic nonabsorbable material, followed by timely suture removal, is preferable to the use of absorbable suture materials, many of which are twisted or braided and have capillary action that wicks contamination into deeper tissues when used in skin. Delayed-absorbable suture materials have the same problems as nonabsorbable materials when neglected and not removed.

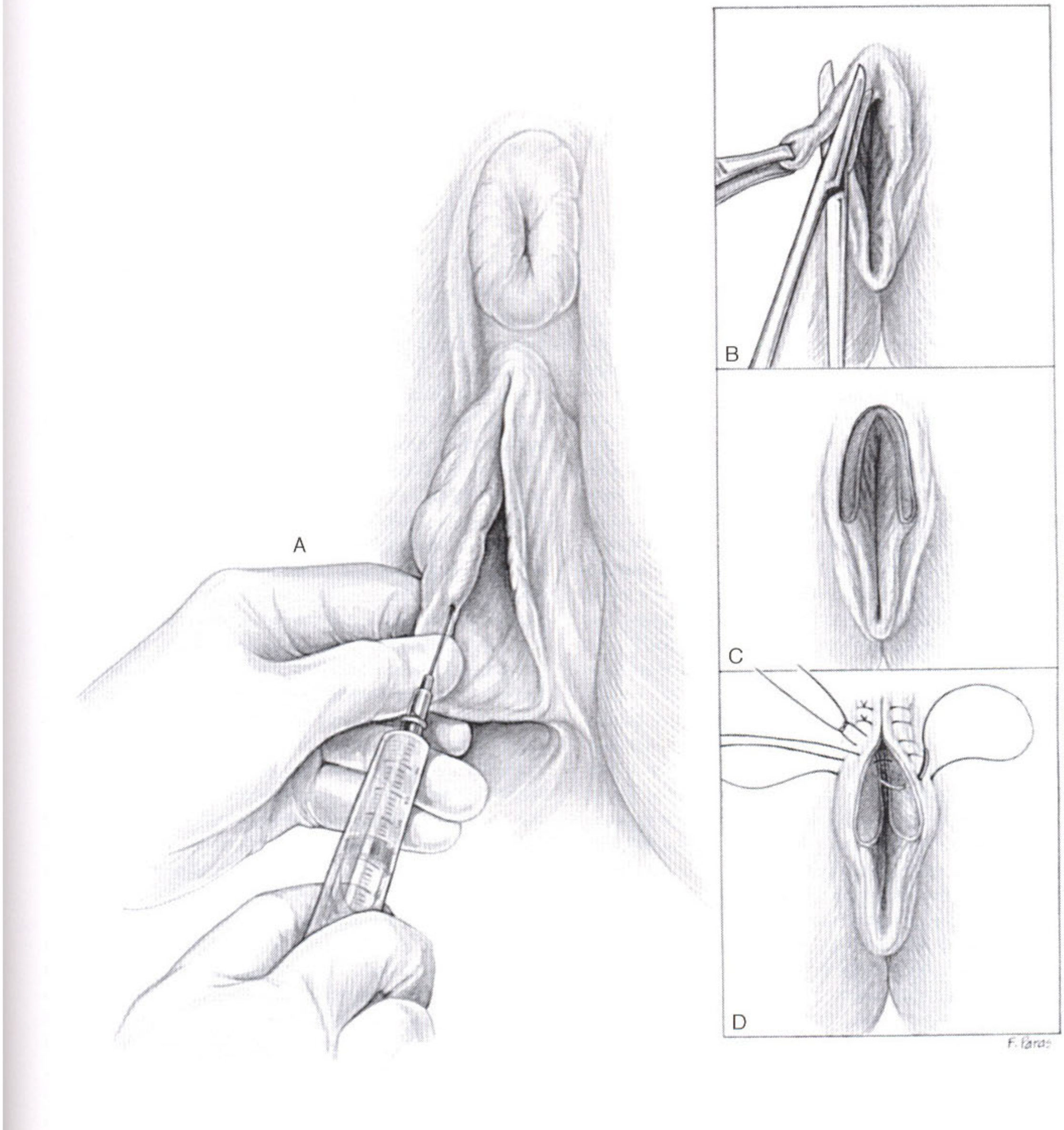
The opening of a vulvoplasty, referred to as episiostomy,[2] should be performed with a sharp scalpel. Local anesthesia frequently is unnecessary. When laypeople perform the opening with a pocketknife, or when tearing occurs with breeding or foaling, the resultant scar tissue can detract from successful reoperation. In broodmares, the vulvoplasty can be redone 24 to 48 hours after parturition.

[a]Prolene, Ethicon, Inc., Somerville, NJ.

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Figure 46–1.



chapter 47

Urethral Extension for Treatment of Vesicovaginal Reflux

Vesicovaginal reflux, commonly termed *urine pooling,* occurs during micturition when the stream of urine is incompletely voided from the vestibule and urine pools in the cranial vaginal fornix. The urine causes or accentuates vaginitis and cervicitis, and urine may enter the uterus during estrus, causing endometritis.[1] Vesicovaginal reflux is associated with a decreased conception rate and early embryonic death. Older multiparous mares are most likely to have vesicovaginal reflux. These mares often have a sunken anus, faulty perineal conformation, a cranioventral slope to the vagina, and a cranially displaced urethral opening as a result of relaxation and falling forward of pelvic and abdominal viscera.[1] The severity of vesicovaginal reflux is related to the severity of these abnormalities.

Vesicovaginal reflux is usually associated with other reproductive problems. Pneumovagina is often present. Air in the vagina may predispose to vesicovaginal reflux by contributing to the loss of the normal vaginovestibular seal. A thorough reproductive evaluation before surgery is recommended to detect other reproductive problems and to identify horses with little potential for conception. Infertility associated with vesicovaginal reflux must be managed as a complex problem.

The treatment methods for vesicovaginal reflux depend on the cause and severity of the problem. Mares having vesicovaginal reflux only during estrus, when the caudal reproductive tract is relaxed, may be successfully managed by evacuating urine from the vagina before breeding. Mares in poor physical condition may have reduced vesicovaginal reflux after weight gain and conditioning. Vesicovaginal reflux in mares with concurrent pneumovagina may respond to treatment of the pneumovagina; however, it must be noted that extensive episioplasty (Caslick's procedure) may increase vesicovaginal reflux by causing urine to be retained by the closed vulvar lips. Transverse perineal body transection between the rectum and vestibule may be helpful in treating vesicovaginal reflux in mares with severely deformed perineal conformation in which the anus is sunken forward and the vulva is tilted.[2] Caudal relocation of the transverse fold may successfully treat vesicovaginal reflux in mares with minor conformational abnormalities.[2, 3] This procedure is relatively easy to perform. However, the treatment of choice for vesicovaginal reflux in horses with marked cranioventral slope to the vagina, significant abnormalities of the perineum, and severe pooling of urine is urethral extension.

Three basic techniques and several modifications have been described for urethral extension.[4–6] All techniques use mucosa of the transverse fold and vagina to extend the length of the urethra caudally so that urine exits the urethral extension just inside the vulvar labia and is voided without reflux. The main complication of all techniques is partial dehiscence of the newly constructed urethral extension with fistula formation into the vestibule. Fistulas usually occur at the cranial aspect of the urethral extension. The rate of fistula formation appears to be nearly equal for all three procedures.[4–6] We believe the technique originally presented by Shires and Kaneps[5] is the least technically demanding to perform. To be performed successfully, this technique requires loose, redundant vaginal mucosa, which is usually present in older multiparous mares. Mares with vaginal scar tissue, failure of previous procedures, or limited vaginal mucosa are not good candidates for this procedure, and we recommend the other methods.[3, 4, 6]

Surgical Preparation, Anesthesia, and Positioning

Surgery is performed on the standing, sedated mare, preferably restrained in stocks. We use a combination of xylazine hydrochloride and butorphanol or detomidine alone for sedation. Sedation should not be so heavy as to cause the mare to be unstable. Caudal epidural analgesia is obtained by injecting 0.22 mg/kg body weight of lidocaine hydrochloride or mepivacaine hydrochloride and 0.17 mg/kg of xylazine diluted in sterile saline to a total volume of 10 ml into the sacrococcygeal or first intercoccygeal space.[7] The tail is wrapped and tied to one side, and the rectum is emptied of feces. After surgical preparation of the perineum, urine is swabbed from the cranial vagina, and the vestibule and vagina are flushed several times with sterile saline or water. A final surgical preparation of the skin and the perineum should be done.

Surgery is facilitated by using 9- or 10-inch-long needle holders, thumb forceps, and scissors. A head light or flexible light source is helpful. Surgery can be performed using a standard floor model surgery light provided that an assistant constantly positions the light during surgery. Modified Finochietto self-retaining retractors[a] or Balfour retractors[b] modified with 6-inch-long retractor blades are helpful to retract the vulva and caudal vestibule but are not essential. We prefer the Balfour retractors, which can be secured with umbilical tape sutures placed in the skin of the buttocks (Fig. 47–1*A*). When self-retaining retractors are used, excessive lateral retraction should be avoided because this makes apposition of the ventral mucosa of the vestibule more difficult. Adequate retraction and surgical exposure can be achieved by placing two stay sutures of 1/8-inch umbilical tape in the skin on each side of the vulvar commissure and securing the sutures laterally to the skin of the buttocks. The skin of the buttocks should be desensitized by the subcutaneous injection of 3 to 4 ml of local anesthetic at each suture site. Towel clamps can be used in place of sutures, but we find that the clamps often are in the way and do not retract as well as sutures.

Surgery

With the vulva retracted laterally, a no. 30 French Foley catheter[c] or sterile rubber tubing 1/2 to 3/4 inch in diameter is inserted through the urethral orifice into the bladder (see Fig. 47–1*A*). A large tube reduces the chance of creating a urethral extension with a narrow diameter, which may restrict urine flow. The Foley catheter is secured by distending the cuff with saline. Alternatively, the tube can be sutured into place at the ventral commissure of the vulva. Interrupted horizontal mattress sutures using size 0 polyglycolic acid[d] or polyglactin 910[e] suture material are placed in the ventral vestibular mucosa to form a tunnel over the tube (Fig. 47–1*B*). Each suture is positioned far enough laterally in the mucosa on each side of the tube so that, when the mucosa is pulled over the tube, little tension exists in the tunnel. The horizontal mattress sutures should be placed in a fashion to create generous ridges of mucosa over the tube (Fig. 47–1*C*). The surgeon should ensure that the tunnel begins cranial to the original urethral orifice to preclude fistula formation at that point. The tunnel should extend caudally to a point about 2 cm cranial to the vulva. After the tunnel has been created and checked to ensure minimal tension over the tube and on the ventral vestibular mucosa, the everted ridges of mucosa dorsal to the horizontal mattress sutures are cut off with scissors, leaving four cut edges of mucosa (Fig. 47–1*D*). All mucosa forming the tunnel cranial to the original urethral orifice must be removed so that fresh cut edges of submucosa can be apposed. The cut edges of the vestibular mucosa are accurately apposed with a simple continuous suture pattern using 2–0 polyglycolic acid or polyglactin 910 suture material (Fig. 47–1*E*). Primary healing of the mucosa must occur if fistulas are to be avoided. Hemorrhage is evacuated from the vestibule and vagina, and the urethral tube and retraction sutures are removed. We do not perform episioplasty at the same time as this procedure but wait until the urethral extension has healed.

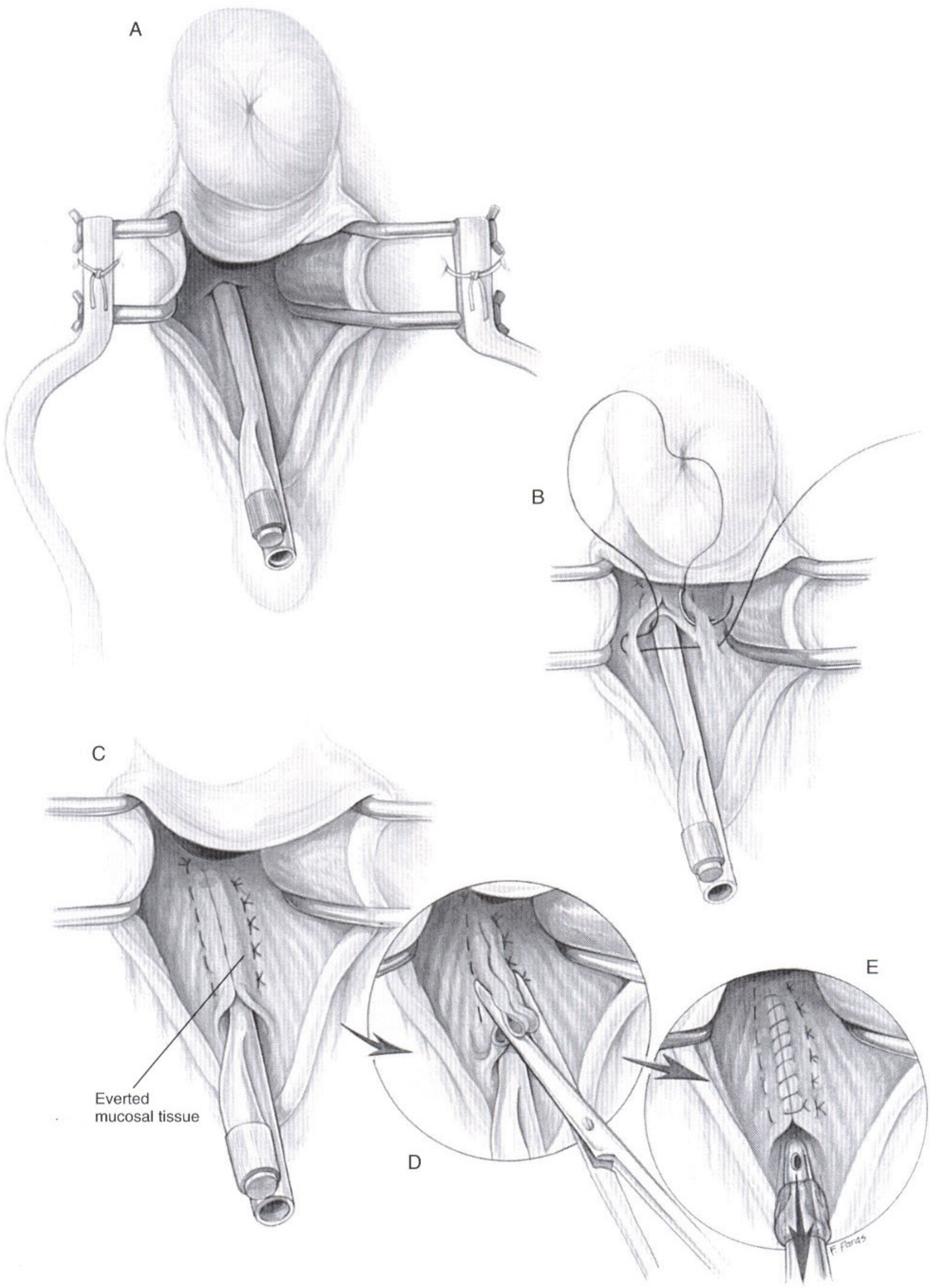
Postoperative Care

The mare should be observed frequently to ensure that urination occurs without difficulty. If dysuria or strangury occurs, the bladder should be palpated per rectum to determine whether urine is being retained. A small urinary catheter or no. 18 French Foley catheter can be inserted into the bladder for several days when urine retention occurs. Analgesics can be administered if postoperative pain occurs. Antibiotics are unnecessary.

The urethral extension should heal in 7 to 10 days, after which time the repair can be examined for fistula formation. Fistulas usually form at the cranial aspect of the urethral extension. Not all fistulas result in recurrence of vesicovaginal reflux.[6] If vesicovaginal reflux occurs because of fistulas, the fistulas should be repaired 3 to 4 weeks after the first surgery by freshening the edges of the mucosa and reapposing fresh-cut tissues. Mares with uncomplicated healing of the urethral extension can be bred in 7 to 10 days by artificial insemination or in 30 days by natural cover provided that the uterus is normal.

[a]Aanes retractor, Sontec Instruments, Englewood, CO.
[b]Balfour retractors, Sontec Instruments, Englewood, CO.
[c]Foley catheter, Rüsch, Duluth, GA.
[d]Dexon "S," Davis & Geck, Inc., American Cyanamid Co., Manati, PR.
[e]Vicryl, Ethicon, Inc., Somerville, NJ.

Figure 47–1.



chapter 48

Rectovestibular Fistula Repair

Rectovestibular fistulas are the result of perineal lacerations from the dorsum of the vestibule into the rectum, often without disruption of the perineal body or anal sphincter.[1] Most rectovestibular fistulas are the result of dystocia, whereby a foot or muzzle of the fetus is forced through the vestibule into the rectum but then retracts or is manually replaced into the normal birth canal before delivery occurs. Rectovestibular fistulas may be close to the perineum or deep (cranial) in the vestibule. Immediate surgical repair of rectovestibular fistulas often fails because the tissues are torn, bruised, edematous, and contaminated. Surgical repair is usually delayed 4 to 6 weeks. Small rectovestibular fistulas may close spontaneously with granulation tissue formation and by wound contraction, but many fistulas require surgical repair. Some surgeons prefer to convert rectovestibular fistulas to third-degree perineal lacerations and repair them by one of the standard methods.[1–3] We recommend conversion of fistulas to third-degree perineal lacerations only when the fistulas are caudal and only a thin strip of tissue separates the fistula from the perineum. The perineal body in caudal fistulas may be partially disrupted. Repair of third-degree perineal lacerations is described in Chapter 49. Other surgeons approach the repair of rectovestibular fistulas by perineal body transection. A transverse skin incision equidistant between the anus and dorsal commissure of the vulva is made, and the dissection is carried cranially through the perineal body to the fistula.[1, 4, 5] Surgical exposure of the fistula, particularly in the cranial aspect of the vestibule, is often limited.

Direct repair of rectovestibular fistulas through the vulva in anesthetized horses has been reported.[6] We prefer to repair rectovestibular fistulas by a direct approach through the rectum in the standing horse, leaving the anal sphincter and perineal body intact.[7] In addition to the standing approach, the advantages of the direct repair are that (1) the perineal body and anal sphincter are not disrupted, leading to less postoperative swelling and pain; (2) the fistula is closed in a transverse direction, minimizing tension and stricture in the rectum; and (3) a thick shelf between the rectum and vestibule can be constructed from fresh-cut tissue edges. To optimize the results of rectovestibular fistula repair, a number of principles of perineal surgery should be used. First, a strong suture material that maintains holding power for at least 10 to 14 days should be used. Second, maximum apposition of freshly incised healthy tissues should be achieved. Third, the tissues should be apposed under minimal tension. Last, the diet should be altered so that feces are soft and reduced in volume for 7 to 10 days after surgery.[8] Firm, dry feces can result in obstipation, straining, and breakdown of the repair.[1]

Anesthesia, Positioning, and Surgical Preparation

Before surgery, a thorough reproductive evaluation, including a uterine biopsy, should be done to identify any breeding mares with little chance of conceiving. The feces should be soft and low in volume. Horses on lush pasture generally have suitable fecal consistency. When pasture is not available and feces are firm, a number of dietary changes can be used to alter the consistency of the feces.[1, 4] We often feed horses low-roughage complete pelleted feeds and administer mineral oil every other day for 3 to 5 days before surgery. Dietary changes should be made gradually. Feed should be completely withheld for 18 to 24 hours before the surgery. Some surgeons recommend administering perioperative antibiotics and anti-inflammatory drugs.[1, 4, 5] The value of perioperative antibiotics has not been established for retrovestibular fistula repair in horses, but the surgical site is always contaminated. Tetanus prophylaxis should be ensured before surgery.

The mare should be placed in stocks and sedated. The tail is wrapped. Regional analgesia for surgery is achieved by caudal epidural analgesia using 0.17 mg/kg body weight of 10% xylazine and 0.22 mg/kg body weight of 2% lidocaine hydrochloride or mepivacaine hydrochloride diluted to a total volume of 10 ml. This combination of drugs provides a rapid onset of analgesia and duration of action of approximately 5 hours.[9] The tail is tied to one side, and feces are evacuated from the rectum and vestibule. A rectal tampon made of rolled cotton is placed in the rectum cranial to the fistula. The rectum, vestibule, and vagina are thoroughly cleansed with dilute povidone-iodine solution and copious amounts of sterile water or saline. All particulate fecal matter should be removed. The surgical site is dried with cotton.

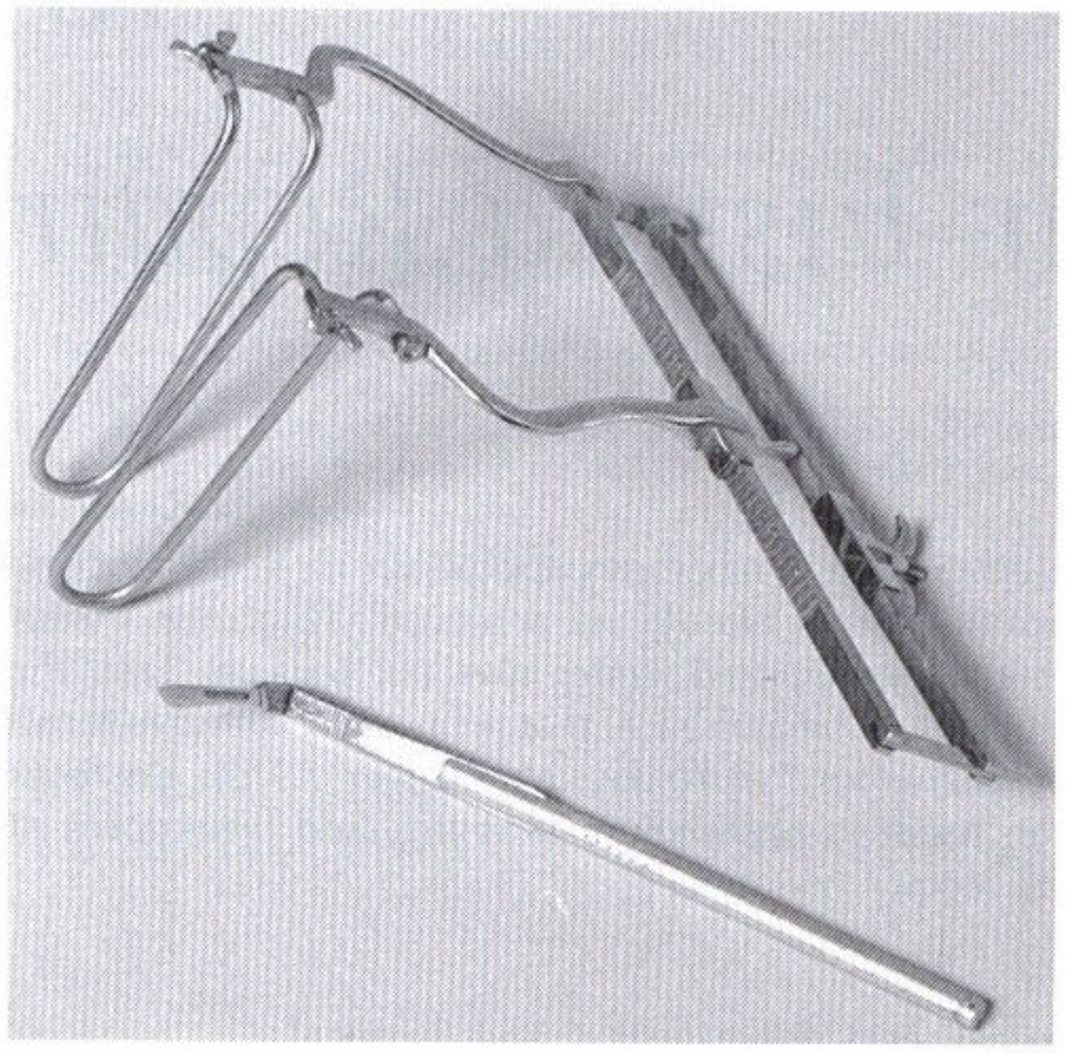


Figure 48–1.

The modified Balfour retractor and modified scalpel handle used for repair of rectovestibular fistulas.

Self-retaining retractors with large blades are necessary to dilate and hold open the anal sphincter. We use a Balfour retractor,[a] which we have modified by making 6-inch-long retractor blades (Fig. 48–1). A modified Finochietto retractor[b] with long blades can be purchased commercially. A hand-held malleable retractor or Sauerbruch retractor and an assistant are also useful but not mandatory. The surgeon should have a 10- to 12-inch-long thumb forceps, needle holders, Mayo scissors, and a no. 3 scalpel handle that has been modified by bending the end so the blade is 80° to the long axis and by extending the handle length 6 inches (see Fig. 48–1).

Surgery

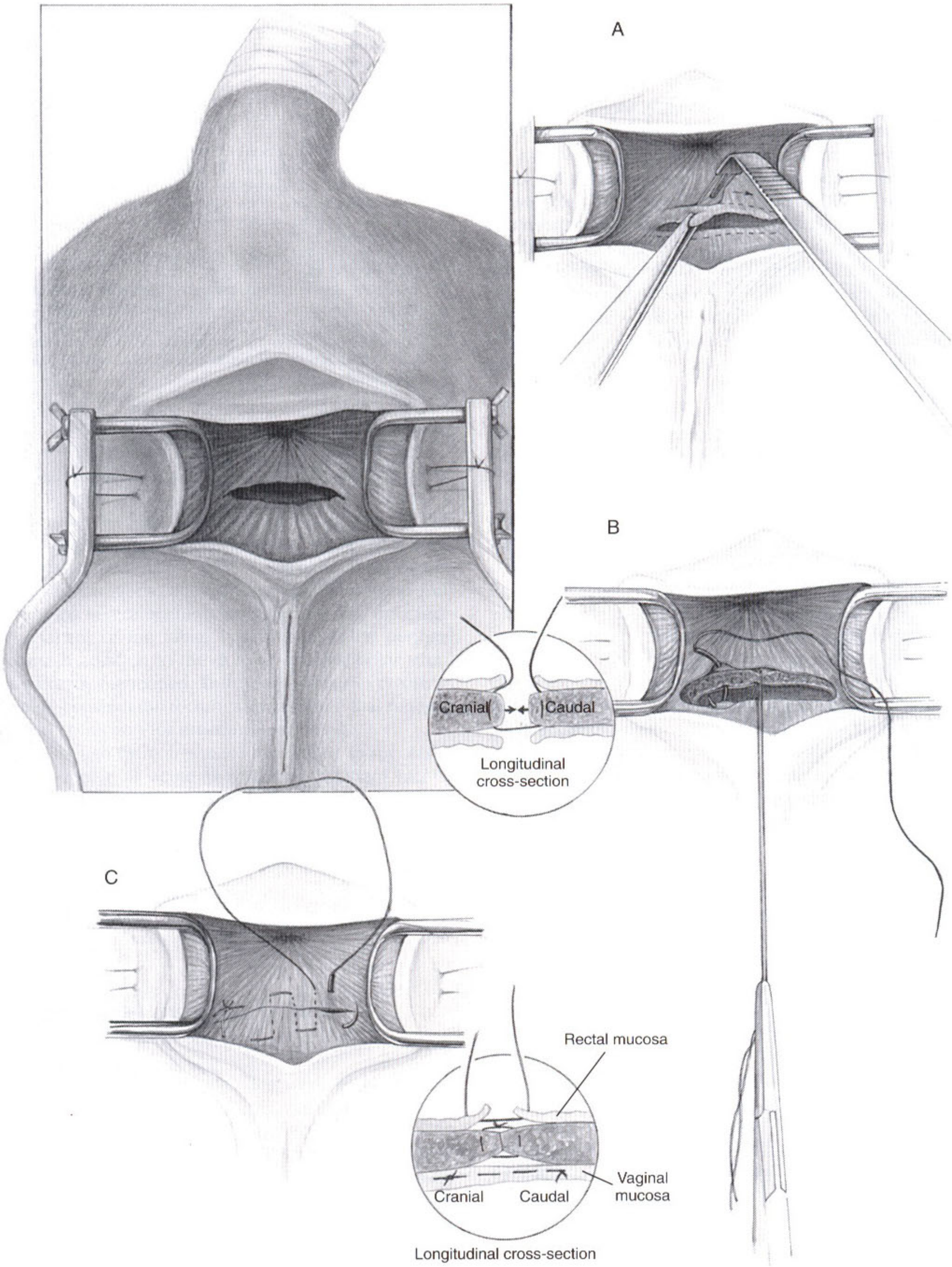
The anal sphincter is dilated using self-retaining retractors. The retractors are prevented from slipping out of the rectum by placing sutures of ⅛-inch umbilical tape on each side of the anus and tying the ends of the sutures around the arms of the retractors.

Working through the rectum, the edge of the fistula, where rectal and vestibular mucosa have healed together, must be completely incised with a 360° circumferential incision. The entire margin of the fistula must have freshly incised edges of rectal and vestibular mucosa. Using a thumb forceps to grasp the edge of the fistula on the cranial midline (the 12 o'clock position), the bent scalpel handle and blade are used to make a full-thickness transverse incision on the cranial aspect of the fistula (from the 11 o'clock to the 1 o'clock position) 5 to 8 mm cranial to the margin of the healed fistula (Fig. 48–2*A*). The 80° angle of the scalpel blade allows the incision to be made transversely while working through the anal sphincter. The caudal edge of the fistula is grasped with a forceps on midline (the 6 o'clock position) and is tensed cranially, and a full-thickness transverse incision is made from the 7 o'clock to the 5 o'clock position with the scalpel blade caudal to the margin of the fistula. These incisions are then connected using scissors to remove the margins of the fistula on both sides (the 7 o'clock to the 11 o'clock and the 5 o'clock to the 1 o'clock positions), thus creating fresh-cut edges for the entire circumference of the fistula.

Closure is done with three lines of sutures. The first line for closure of the defect is accomplished by incorporating three distinct layers in each suture: the rectal submucosa, the perineal fascia, and the vestibular submucosa. This pattern is important for strength and seal. Large interrupted sutures of size 1 polydioxanone[c] are used to approximate the tissues in a transverse direction in relation to the longitudinal axis of the rectum. Transverse repair minimizes reduction of the lumen of the rectum. Each suture is placed from rectal submucosa through the perineal fascia and into vestibular submucosa on the cranial side of the fistula and then through vaginal submucosa, perineal fascia, and rectal submucosa on the caudal side (Fig. 48–2*B*). Sutures should be placed 6 to 8 mm apart, and deep bites should be taken in the perineal fascia. All sutures are preplaced; the ends are left long and tagged with hemostats (see Fig. 48–2*B*). This allows the surgeon to place each subsequent stitch properly while working through the rectum. When sutures are tied as they are placed, it is difficult for the surgeon to position subsequent sutures in a proper craniocaudal direction because needle-holder movement is limited through the anal sphincter. A flat-blade retractor may be needed to retract the anal sphincter and rectum dorsally for placement of some of the sutures. After all sutures are placed, they are tied snugly to close the fistula. Any gaps are closed with additional sutures. The second line of sutures closes the rectal mucosa transversely with a continuous horizontal mattress suture pattern using size 1–0 polydioxanone suture material (Fig. 48–2*C*). The Balfour or Finochietto retractor is removed from the rectum and repositioned in the vestibule. When the mucosa of the vestibule is loose, it can be closed with a simple continuous or continuous horizontal mattress pattern of size 1–0 polydioxanone suture material in a longitudinal direction (see Fig. 48–2*C*). This positions the vestibular closure perpendicular to the closure of the perineal fascia and rectal mucosa. The vestibular mucosa can be closed in a transverse direction when necessary. The rectal tampon is removed when surgery is complete.

[a]Balfour retractors, Sontec Instruments, Englewood, CO.
[b]Aanes retractor, Sontec Instruments, Englewood, CO.
[c]PDS II, Ethicon, Inc., Somerville, NJ.

Figure 48–2.


A
B
Cranial
Caudal
Longitudinal cross-section
C
Rectal mucosa
Vaginal mucosa
Cranial
Caudal
Longitudinal cross-section

Postoperative Management

The diet should be managed so that the feces are kept soft and low in volume for 7 to 10 days. If obstipation or constipation occurs, the rectum should be gently evacuated of feces as necessary. The major complication to this surgery is dehiscence of all or part of the repaired fistula. Dehiscence should not occur if the feces are soft, the entire edge of the fistula has been properly debrided so fresh edges of the fistula are apposed, and good apposition of the cut edges has been obtained with the sutures. Swelling is minimal because the perineal body and anal sphincter have not been cut.

Provided the rectovestibular fistula has healed and the endometrium is healthy, mares can be bred using artificial insemination in 3 weeks. Endometritis caused by contamination of the vestibule and vagina with feces should resolve within 15 days after surgery.[10] Natural breeding can occur 6 weeks after surgery for most horses.

The prognosis for healing of repaired rectovestibular fistulas is good.[2, 3, 4, 7] In one study, 75% of mares with perineal lacerations or rectovestibular fistulas became pregnant after surgical repair.[2]

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chapter 49

Third-Degree Perineal Laceration Repair

Perineal lacerations and rectovaginal fistulas are caused by parturition in the mare. They occur most frequently in primiparous mares. Perineal lacerations are graded first, second, or third degree based on the severity of the injury. First-degree lacerations involve the vestibular mucous membrane and skin at the dorsal commissure of the vulva. They can be minor injuries that go unnoticed, or they may require episioplasty (see Chapter 46) to re-establish a normal vulvar seal. Second-degree lacerations disrupt muscular elements of the perineal body and the vulvar constrictor muscles in addition to the skin and vestibular mucosa. Healed second-degree lacerations predispose to pneumovagina and fecal contamination of the vestibule. Third-degree perineal lacerations involve the musculature and mucosa of the ventral rectum, the sphincter ani, the cruciate segment of the labial ligament, and the perineal septum in addition to the dorsal vulvovestibular structures already mentioned. Third-degree injuries create an opening between the rectum and vestibule that requires surgical correction for breeding soundness.

Although there are anecdotal reports of successful primary repair of acute third-degree perineal lacerations, such attempts usually fail. After injury, mares should receive emergency wound treatment and be monitored for peritonitis, pelvic cellulitis, and systemic illness for the first 5 to 7 days. The surgery should be postponed until open wound healing is complete (4–6 weeks). If the mare is lactating, surgery should be deferred until the foal is weaned.

Anesthesia, Positioning, and Surgical Preparation

Preoperative nutritional management is essential to a successful outcome. It is not necessary to reduce the bulk in the colon, but the patient must have soft, unformed feces at surgery and for several days thereafter. At one extreme, watery feces or diarrhea will wash fibrin from the sutured tissues and lead to postoperative breakdown. At the other extreme, firm feces leading to rectal constipation will induce straining. The manipulation and enemas necessary to relieve constipation during the first several days after surgery can lead to suture breakdown. Spring or early summer grass pasture is an ideal diet for producing soft unformed feces. Because of the disturbing effects of feed changes on the gastrointestinal tract, the mare should be adjusted to any nutritional changes for 7 to 10 days before surgery. Feed and edible bedding can be withheld 12 hours before surgery to help reduce the gastrocecocolic reflex and the tendency to defecate during surgery, but water should be available. Three to 4 L of mineral oil[a] should be given per os 12 to 18 hours before surgery with the intent of further softening and lubricating the bowel contents that will initially pass over the reconstructed tissues. We do not believe that mineral oil interferes with the healing of a properly reconstructed laceration.

The surgery can be tedious and acrobatic. A tall surgeon standing behind a small mare may become uncomfortable because of the size disparity. However, dorsal positioning of the patient under general anesthesia completely distorts the anatomic relationships and is not recommended. General anesthesia and sternal positioning have been used; careful positioning and padding are essential. This surgery entails a three-dimensional reconstruction of tubular anatomy. The tissue relationships are best viewed and reconstructed in their normal anatomic position with the horse standing.

Epidural anesthesia can be induced with an 18-gauge, 1.5-inch needle in the mare. However, there is frequently incomplete desensitization of the perineal region with poor rostral diffusion of the anesthetic agent. Mares that have had previous epidural injections are particularly prone to incomplete desensitization, apparently because of a chemically induced adhesive arachnoiditis in the coccygeal region. These problems can be circumvented by aseptically threading a curved 8- to 10-cm, 19-gauge spinal needle rostrally in the epidural canal from the S5-C1 or C1-2 intervertebral space (see Chapter 2). Up to 8 ml of 2% lidocaine hydrochloride with epinephrine can be deposited at this site without fear of recumbency in an adult horse.

[a]Mineral oil 95V, The Butler Co., Columbus, OH.

The epidural lasts up to 90 minutes. The needle with stylet can be left in position to augment anesthesia during surgery. Xylazine hydrochloride,[b] 0.17 mg/kg, and lidocaine hydrochloride, 0.22 mg/kg diluted to a 10-ml volume, provides excellent, safe epidural analgesia lasting more than 2 hours.[1] This drug combination requires 20 to 30 minutes to take effect but is not accompanied by hindlimb ataxia and is the preferred epidural agent. Local anesthetic infiltration of the tissues is performed intraoperatively when desensitization from the epidural is incomplete. Tractable mares can be operated on without chemical sedation. An assistant standing quietly at the horse's head can have a calming effect. Heavy chemical sedation combined with epidural anesthesia can cause hindlimb unsteadiness, leading to restlessness and shifting of the mare and frustration for the surgeon. When necessary for fractious horses, sedative drugs should be used in the lowest effective dosages.

While the xylazine epidural is taking effect, the tail is bandaged and tied out of the field, the rectum is emptied of feces, and the vagina and vestibule are lavaged with dilute antiseptic solution. The perineum is clipped, and the vulva, anus, and cloaca created by the perineal laceration are scrubbed with surgical soap and rinsed with sterile polyionic solution. The surgery involves a high possibility of intraoperative contamination with urine, rectal mucus, or feces and is classified as contaminated surgery. Drapes are not essential, but the surgeon should scrub, don sterile gloves, and use autoclaved instruments. Perioperative antibiotics for the decisive period of surgery are commonly recommended, but we do not use them in otherwise normal patients. Antibiotics will not compensate for poor surgical technique, lack of experience, and postoperative problems, such as constipation, that threaten healing.

Currently, two methods of suture repair of third-degree lacerations are favored: the Goetze method, or eight-bite technique, and the Aanes method, based on a layered closure.[2, 3] Both techniques are amenable to a variety of modifications and can be performed in stages. It is acceptable to repair the tubular rectum and vagina in one stage and to perform a vestibuloplasty as a second stage. Episioplasty can be a third stage. The entire repair can be successfully performed as a single operation.[4] The multiparous mare with a stretched ovariouterine suspension and ventrally sloping vagina may benefit from a staged approach to repair. We favor the Aanes method, which will be described.

Dissection and reconstruction involve manipulation of the distinct mucosal layers of rectum and vagina and the scarred perineal tissues. The surgery must create a thick shelf between the roof of the vestibule and the floor of the rectum. Suturing must create a leakproof shelf free of tension. All tissues are saved and incorporated in the closure. The scar tissue from the original injury aids suture line integrity and is sufficiently vascular for healing. Previous literature indicates the need to develop a thick rectal floor.[2] The Aanes approach can be successful without apposition of the rectal mucosa. We prefer to create a thick vestibular and perineal shelf as the primary reconstruction and then suture the rectal mucosa over the shelf as a seal against gross contamination.

Surgery

Depending on the size of the operator's hands and the depth of the laceration, long instruments may be useful. A person with large hands cannot work with standard instruments and see the dissection. Mechanical retractors may be helpful, but they tend to slip out of place and obscure the field of dissection. Manual retraction by pulling on stay sutures placed on each side of the perineal laceration provides the best exposure. Because the anatomic defect varies from case to case, variable placement of the stay sutures and moment-to-moment adjustment by "human" retractors aids the reconstruction.

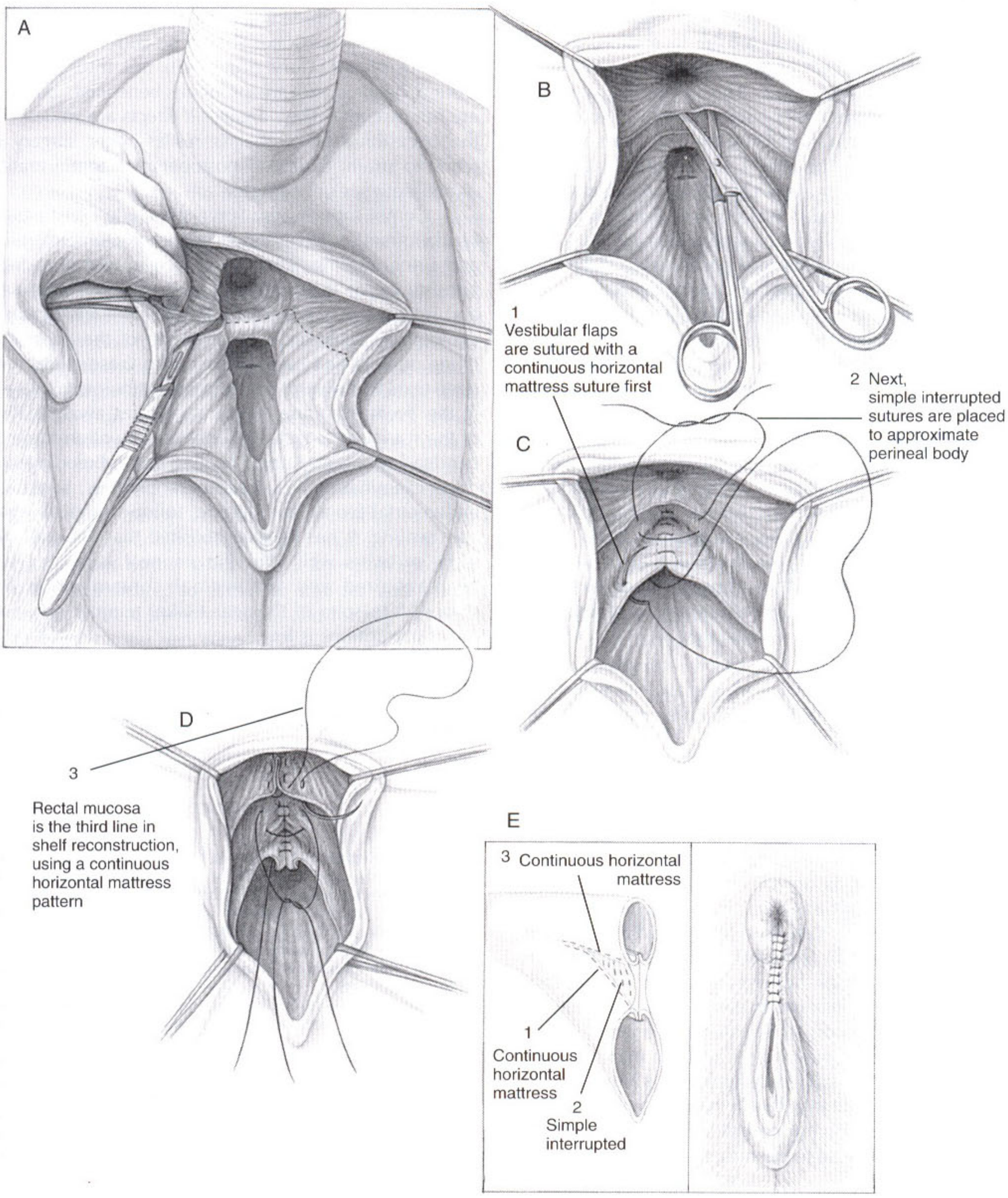
Using sharp incision with a scalpel blade, the rectal and vestibular mucous membranes are separated in a horizontal plane from the skin caudally to the intact perineal body rostrally (Fig. 49–1*A*). The rectum and vagina are sharply separated at the cranial aspect of the tear for 5 to 6 cm so that suturing can begin in normal tissue and extend caudally into the previously lacerated area (Fig. 49–1*B*). Flaps of rectal and vestibular mucosa are created from each wall of the cloaca. The flaps should be large enough to be apposed under minimum tension. The blood supply to these flaps is sufficient for healing, but intraoperative hemorrhage is not a problem.

Proper suture material selection is fundamental to the success of this surgery. We prefer size 1 polydioxanone[c] armed with a swagged-on half-circle taper needle for reconstruction of the vestibular flaps and perineal body. This is a strong, delayed-absorbable monofilament synthetic suture with excellent tissue compatibility. As a "plastic" suture, it elongates with tissue swelling, reducing the possibility of tissue strangulation. The vestibular flaps are sutured first using a continuous horizontal mattress pattern as viewed from the mucosal surface of the vestibule (Fig. 49–1*C*). The suture line is started rostrally in the normal vagina and continued caudally, being kept tight to create a good seal. The perineal body is approximated with simple interrupted sutures placed 1 cm apart. This second line closes redundant tissue and reinforces the vestibular mucosal layer. These sutures are also started in the normal tissue rostral to the laceration (see Fig. 49–1*C*). The rectal mucosa is sutured as the third line in shelf reconstruction using a continuous horizontal mattress pattern of

[b]Rompun, Miles Inc., Shawnee Mission, KS.

[c]PDS II, Ethicon, Inc., Somersville, NJ.

Figure 49–1.


A
B
1
Vestibular flaps
are sutured with a
continuous horizontal
mattress suture first
2 Next,
simple interrupted
sutures are placed
to approximate
perineal body
C
D
3
Rectal mucosa
is the third line in
shelf reconstruction,
using a continuous
horizontal mattress
pattern
E
3 Continuous horizontal
mattress
1
Continuous
horizontal
mattress
2
Simple
interrupted

size 0 polydioxanone, with the mucosa everted into the rectal lumen (Fig. 49–1*D*). For deep, sloping tears, completion of one layer may preclude visibility for closing subsequent layers. All three suture lines are started in the rostral aspect of the laceration, and, in alternating fashion, part of each layer is closed until the entire shelf is constructed. The perineum is reconstructed with the vestibuloplasty technique.[2] No effort is made to identify or approximate the torn anal sphincter. Simple interrupted ("quilting") sutures of size 0 polydioxanone are used to approximate the perineal tissues between the anus and dorsal commissure of the vulva (Fig. 49–1*E*). Perineal skin closure is routine.

Fecal contamination of exposed tissue during surgery is common but does not of itself lead to dehiscence. Copious lavage and moist sponging with sterile saline throughout surgery usually negates an adverse effect on healing. Older literature admonishes the surgeon not to penetrate the rectal mucosa with suture material, yet we have done so for years, believing that the seal against gross contamination is more important than capillary invasion of bacteria along suture tracks. The key to successful repair is the thickness and seal of the perineal body. Thin shelves will break down, particularly if postoperative straining or constipation occurs. Loose sutures will lead to fistulas, which usually form rostrally. Imposition of mucosal tissue into the fascial layers will result in failure; granulation tissue cannot "heal" to epithelial structures.

Postoperative Management

Light feeding is resumed immediately. The mare is observed frequently during the first 36 hours for evidence of straining and defecation. Most mares elevate the tail slightly for 2 to 3 days after surgery. This should not be confused with straining or reluctance to defecate. Straining is uncommon, but when it occurs the results can be disastrous. It usually accompanies constipation, which can lead to wound breakdown. Constipation must be relieved gently and quickly by manual evacuation of the rectum. Mild tranquilization is the best way to manage straining and restlessness. If it is necessary to resort to repeated epidurals, a serious underlying problem may exist. Once the mare is eating and defecating regularly, usually within 12 to 24 hours of surgery, further aftercare is unnecessary.

Curiosity about the progress of healing must be suppressed. The rectal temperature is not taken. Digital examination of the suture line is withheld until day 10. Rectal palpation is postponed for at least 30 days. Rebreeding by artificial insemination can begin after 30 days and natural breeding after 90 days.

Tetanus prophylaxis should be current. Nonsteroidal anti-inflammatory drugs will not interfere with wound healing and are probably beneficial, but they are not essential. Their analgesic effects are valuable in the occasional horse that is restless after surgery or tends to strain. Extended postoperative administration of antibiotics is unnecessary.

Complications after surgery include constipation, fistula formation, dehiscence, pneumorectum, infertility, and urine pooling. Their incidence is related to fecal consistency at the time of surgery and the thickness and integrity of shelf reconstruction. Pneumorectum is avoided by anatomic reconstruction of the perineum. Urine pooling and infertility occur in those mares with deep tears that disrupt the normal vestibulovaginal seal. In the event of failure, reoperation must await healing of the fistula or cloaca (4–6 weeks). Attention to detail can lead to a high rate of healing and rebreeding success. Examination for breeding soundness, including endometrial biopsy and culture, follows surgical repair and healing. It has been established that the endometrium recovers well after the perineal laceration has been repaired and the vaginal contamination has stopped.[5] In spite of the scar tissue, reinjury at subsequent parturitions is low.[6]

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chapter 50

Ovariectomy

Ovariectomy in the mare is a major surgical procedure that can be difficult because of limited exposure to the ovaries, lack of visualization, and problems achieving hemostasis of the severed ovarian pedicle. The most common indication for removal of one ovary is the granulosa cell tumor.[1] Unilateral ovariectomy has been performed for other ovarian tumors, ovarian cysts, and ovarian abscesses.[1–4] Granulosa cell tumors usually cause enlargement of the ovary, altered estrous cycles, and behavioral changes. Granulosa cell tumors should be differentiated from other causes of enlarged ovaries such as cysts, hematomas, and persistent follicles, which do not require ovariectomy. The diagnosis of granulosa cell tumors is confirmed by rectal examination, ultrasonography, and the determination of inhibins concentrations in the serum.[3, 5, 6] Bilateral ovariectomy in mares is indicated to eliminate objectionable estrous behavior, to treat nymphomania, and to prepare mares as embryo transfer recipients.

There are numerous approaches to ovariectomy in mares. Bilateral removal of normal-sized ovaries can be performed by standing flank laparotomy, standing colpotomy (incision of the vagina), and ventral midline or paramedian incisions in the anesthetized mare. Laparoscopic ovariectomy in standing horses has also been described.[7] Unilateral ovariectomy of granulosa cell tumors and other enlarged ovaries can be performed in anesthetized horses by a flank approach, a ventral midline laparotomy, a standard paramedian laparotomy, or a diagonal paramedian approach.[8] Enlarged ovaries usually have a very vascular ovarian pedicle, which must be ligated securely to prevent postoperative hemorrhage. This requires exposure of the ovary and visualization of the pedicle. Factors used to select a surgical approach to ovariectomy include number of ovaries to be removed, size of the ovary to be removed, length of the ovarian pedicle, mare's temperament and size, condition of the reproductive tract, surgeon's experience and preference, availability of an écraseur, other patient risk factors, and cosmesis. Elective bilateral ovariectomy to eliminate objectionable estrous behavior should not be performed while the mare is in heat (estrus), because ovarian vascularity will be increased and hemorrhage more likely.

Approaches

Flank

A standing flank approach can be used for bilateral ovariectomy in horses with normal-sized ovaries (Fig. 50–1*A*). The far ovary cannot be exteriorized, and hemostasis of the ovarian pedicle is achieved by use of an écraseur.[a] This technique is not recommended in nervous or fractious mares, in mares with little space between the ribs and tuber coxae, or for removal of abnormal ovaries. The flank approach with the mare anesthetized and positioned in lateral recumbency can be used for removal of granulosa cell tumors smaller than 25 cm in diameter. Anesthesia relaxes the muscles of the flank and eliminates movement during ligation of the ovarian pedicle. The position of the ovary and the length of the pedicle should be determined by rectal examination before surgery. The flank approach is useful when the ovarian pedicle is short and exteriorization of the ovary through a ventral midline or paramedian approach will be difficult. Ovaries positioned at or above the brim of the pelvis are better exposed through a flank incision than with the ventral approaches. The surgeon may need to decrease the diameter of the ovaries with granulosa cell tumors in order to exteriorize them through the incision by aspirating fluid from the cystic spaces. We use a long 16-gauge needle attached to suction, but a large syringe can also be used for aspiration.

Midline

The ventral midline laparotomy is versatile and can be used for bilateral ovariectomy or unilateral removal of tumorous ovaries.[4] The ventral midline incision is easy to make and to close, most surgeons are confident in the approach, and the length of the incision can be extended to improve access and exteriorization of ovaries. Many surgeons prefer this approach for all ovariectomies, and we use this approach frequently. The incision starts just cranial to the mammary glands and extends cranially for 25 cm (Fig. 50–1*B*). Normal ovaries have short pedicles and are difficult to exteriorize. Access to normal ovaries can be improved by using large Balfour[b] or Finochietto[c] retractors on the body wall and isolating the ovary and pedicle from the abdominal viscera by putting a small hole in a sterile plastic drape and pulling the ovary through the hole. The drape can then be pushed down around the pedicle to keep viscera out of the field of surgery during ligation of the pedicle. Access to the ovary can also be improved by having an assistant push down on the body wall to bring the ovary closer to the incision. The ventral midline laparotomy is described in Chapter 16.

Diagonal Paramedian Laparotomy

A standard paramedian laparotomy can be used for unilateral removal of tumorous ovaries or for bilateral removal of normal ovaries. Some surgeons prefer the ventral paramedian approach over the ventral midline. We see no advantages to the standard paramedian incision compared with a ventral midline incision. However, a diagonal paramedian approach for removal of ovarian tumors up to 25 cm in diameter may improve ovarian exteriorization and facilitate ligation.[8] It is difficult to lengthen the diagonal paramedian incision for exposure of larger tumors, and a midline approach is preferable in these instances.

Colpotomy

Ovariectomy by colpotomy is an accepted method of elective bilateral ovariectomy in normal mares to prevent estrus. We do not recommend this procedure for removal of ovarian tumors because of increased vascularity and the risk of severe postoperative hemorrhage. This method leaves no external scars, can result in rapid return to training, and is less costly than methods requiring general anesthesia. A chain écraseur is necessary for removal of the ovaries. This technique has gained popularity in recent years, particularly among owners of Quarter horses used for showing in pleasure classes. Nervous and ill-tempered mares are not good candidates for colpotomy.

Ovariectomy by the Diagonal Paramedian Laparotomy

Anesthesia, Positioning, and Surgical Preparation

Mares should be held off feed 36 hours before surgery. Mineral oil can be administered via nasogastric tube 12 hours before surgery. A nonsteroidal anti-inflammatory drug should be given just before surgery. Perioperative antibiotics are unnecessary, but tetanus prophylaxis should be ensured.

Anesthesia is induced, and the horse is maintained on inhalation anesthesia and positioned in dorsal recumbency. Surgical preparation of a liberal area of the caudal abdomen is performed. Hair should be removed from the mammary gland forward for approximately 60

[a]Chain écraseur, Jorgensen Laboratories, Inc., Loveland, CO.

[b]Balfour abdominal retractor, Baxter Healthcare Corp., Round Lake, IL.

[c]Finochietto retractor, Sontec Instruments, Englewood, CO.

Figure 50–1.

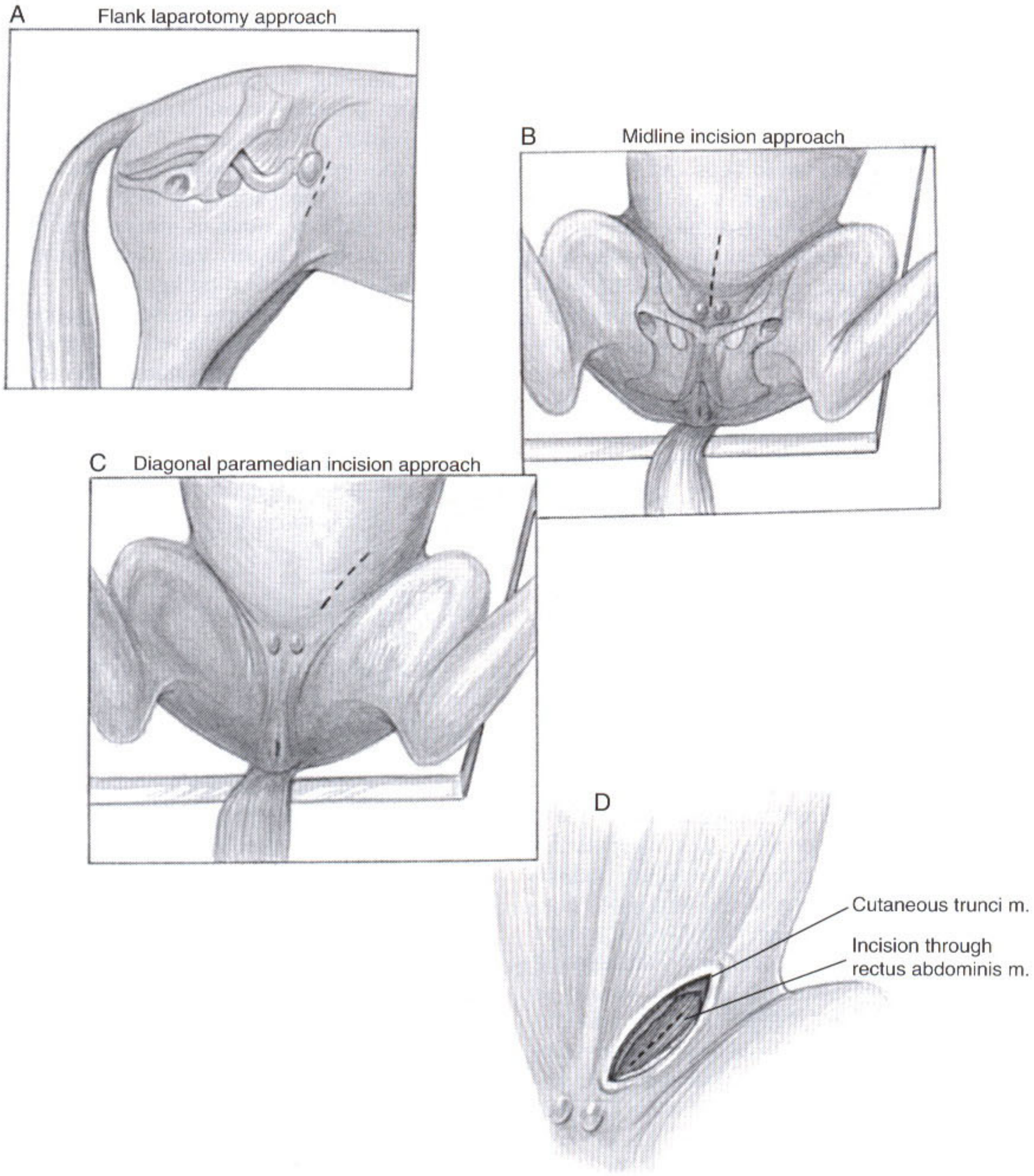


Illustration continued on page 249

cm and laterally to the abaxial side of the fold of the flanks. Routine aseptic skin preparation and draping of the surgical site are essential.

Surgery

A skin and subcutaneous incision is made on the same side of the horse as the tumor starting 5 cm cranial to the mammary gland and extending 20 to 30 cm toward the fold of the flank (Fig. 50–1*C*).[8] The length of the incision depends on the size of the tumorous ovary but is limited by the mammary gland caudally and the fold of the flank cranially. The ventral edge of the cutaneous trunci muscle may be encountered in the cranial aspect of the incision, and it can be incised in the same direction as the skin incision. The superficial fascia is incised, exposing the external sheath of the rectus abdominis muscle, which is incised in the same direction as the skin. The fibers of the rectus abdominis muscle are bluntly separated. These fibers nearly parallel the skin incision because the muscle narrows as it inserts on the prepubic tendon (Fig. 50–1*D*). The

underlying internal sheath of the rectus abdominis muscle and the peritoneum are incised to gain access to the abdomen.

The ovary is located, grasped, and exteriorized. Large cystic ovaries can be reduced in size when necessary by aspiration of fluid from cystic spaces. Access to the ovarian pedicle for ligation and transection can be improved by traction on the ovary with guy sutures of umbilical tape or with vulsellum forceps and by having an assistant push down on the body wall (Fig. 50–1*E*). Ten milliliters of lidocaine is injected into the pedicle at the level of ligation to prevent pain perception and movement during placement of the ligatures. The local anesthetic may also reduce the prevalence of intraoperative hypotension caused by traction and ligation of the ovarian pedicle.

It may be necessary to perform a partial hysterectomy of the uterine horn in horses in which the horn is closely adhered to the ovary. The remaining horn is closed with a Cushing or Lembert suture pattern using size 0 polydioxanone[d] suture material. The ovarian pedicle is often thick and very vascular. Numerous secure transfixation ligatures must be carefully placed before transection of the pedicle to avoid hemorrhage. We place four to eight overlapping transfixation ligatures using size 2 polydioxanone synthetic or size 2 catgut absorbable suture material through the pedicle so that the knots are positioned around the circumference of the pedicle (Fig. 50–1*F*). The ligatures are placed as far from the ovary as possible. As each ligature is being tightened and the knot secured, traction on the ovary should be minimized to reduce tension on the pedicle. A ligature that appears tight on a stretched pedicle may become loose after release of the tension.[4] Large tumorous ovaries obstruct access to the pedicle and make ligation difficult. The peritoneum on the pedicle can be incised with Metzenbaum scissors to aid in identifying the vessels, many of which can be individually ligated. Exposure can be improved when necessary by ligating a portion of the pedicle, severing the ovary from that portion, and repeating the procedure until the entire pedicle is transected.

Transection should occur close to the ovary to leave at least 1 cm of pedicle distal to the ligatures in order to avoid slippage of the ligature off the end of the pedicle. Before complete transection, the pedicle should be secured with several forceps placed distal to the ligatures so the pedicle does not slip into the abdomen. After complete transection of the pedicle, vessels that continue to bleed should be ligated. The pedicle is released into the abdomen after the surgeon is confident that hemorrhage is controlled. An alternative method for ligation of the ovarian pedicle is to use the TA-90 surgical stapling instrument[e] across the pedicle. This instrument provides a rapid, satisfactory method of ligating ovarian pedicles and can be particularly helpful when exposure of the pedicle is limited.[9] Two or three applications of the TA-90 are necessary for most ovariectomies. Stapling alone is not satisfactory for large tumors with thick, highly vascular pedicles but can be combined with transfixation ligatures.

The rectus abdominis muscle is apposed with size 2 polydioxanone suture material using several widely spaced simple interrupted sutures. The external rectus sheath is closed with either simple continuous or simple interrupted sutures with the same material. The subcutaneous tissue is closed with any suitable size 0 synthetic absorbable suture material. Skin closure is routine and depends on the surgeon's preference.

Postoperative Management and Complications

Postoperative pain, presumably arising from the ligated ovarian pedicle, is not uncommon for 24 to 48 hours. Nonsteroidal anti-inflammatory drugs should be administered to control this pain. The occasional mare requires narcotic analgesics for 12 to 36 hours. Mares should be confined to stalls for 2 weeks and then allowed light paddock exercise for 2 weeks. Training, riding, or natural service should be delayed for an additional 4 weeks.

Immediate postoperative complications include rhabdomyolysis, nerve paralysis, hemorrhage, shock, and ileus. Mares should be observed carefully for the first 24 hours after surgery. Other complications that may become apparent several days to weeks after surgery are adhesions, abscesses or hematomas of the pedicle, peritonitis, and incision seromas or infections.

After unilateral ovariectomy, many mares will resume normal reproductive cycles.[1] In one study, 74% of mares undergoing surgery returned to regular estrous cycling in a mean time of 8.5 months (range, 2–16 months) after removal of granulosa cell tumors.[1] Fertility did not seem to be impaired in those mares that resumed estrus.

[d]PDS II, Ethicon, Inc., Somerville, NJ.
[e]TA-90 premium auto suture, U.S. Surgical Corp., Norwalk, CT.

Figure 50–1. *Continued*

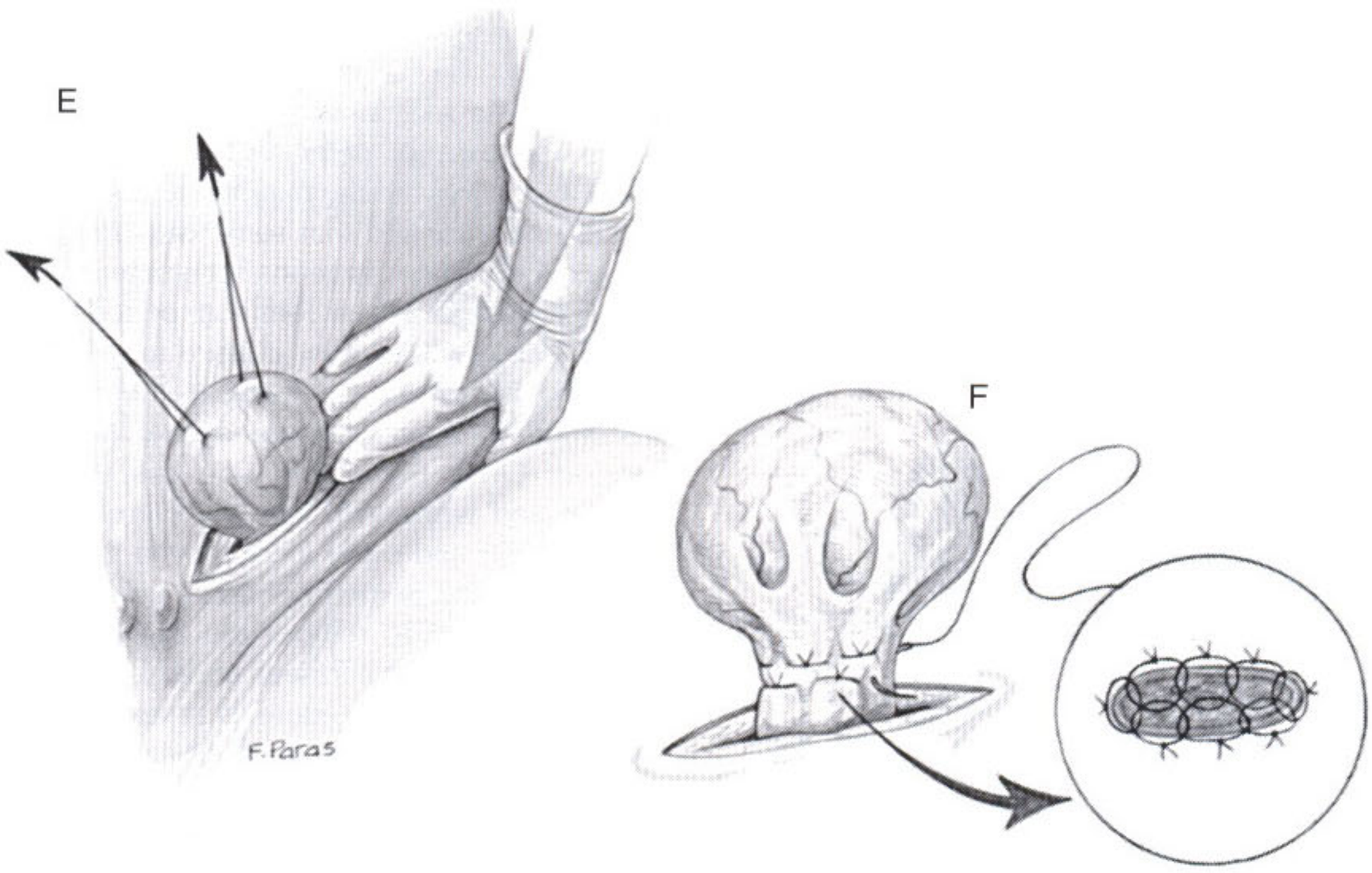


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Ovariectomy by Colpotomy

Anesthesia, Positioning, and Surgical Preparation

Before surgery, the surgeon should ensure that the mare is not in heat and is free of uterine, vaginal, or urinary infections. Some surgeons recommend performing a clotting profile. Feed is withheld for 36 hours, but water is allowed free choice. One gallon of mineral oil may be given 12 hours before surgery. Perioperative penicillin G potassium, 22,000 U/kg as an intravenous bolus, is given just before surgery and again 3 to 4 hours thereafter. The mare should be placed in stocks and restrained with cross-ties. An experienced handler should stay at the horse's head throughout surgery. The mare should be sedated with either xylazine and butorphanol or detomidine. Epidural anesthesia of 0.17 mg/kg of 10% xylazine and 0.22 mg/kg of 2% lidocaine diluted to a total volume of 10 ml is given to reduce intraoperative straining caused by vaginal manipulation. The tail is wrapped and tied overhead. Feces are evacuated from the rectum, and the bladder is catheterized and drained. The perineum undergoes routine surgical scrub, and the vagina is lavaged with warm dilute antiseptic solution. All residue fluids in the vagina should be removed before the procedure.

Surgery

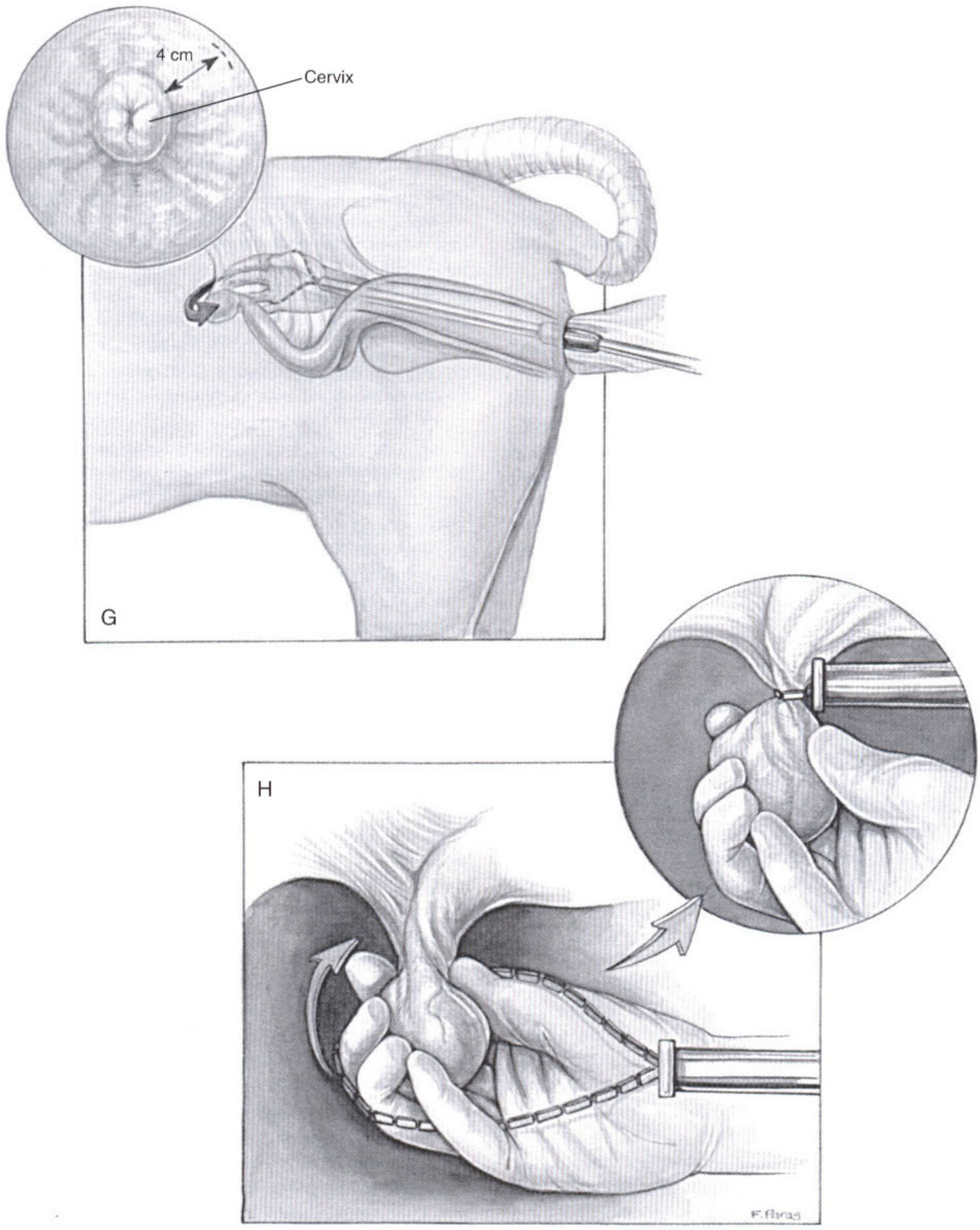
The surgeon should wear a sterile gown and a long sterile impervious glove on the arm to be inserted into the abdomen. Pneumovagina is induced by opening the vestibulovaginal sphincter. Surgical sponges soaked in mepivacaine hydrochloride[f] are held against the cranial vagina at the colpotomy site. The colpotomy is made using a no. 10 scalpel blade that is guarded with the thumb and forefinger while being passed into the vagina. The blade is protruded 2 cm from the thumb and fingers, and a 2-cm-long stab incision is made through the vagina and peritoneum into the abdomen. The incision is positioned 4 cm from the cervix in either the right or left dorsolateral vagina at the 1:30 or 10:30 position (Fig. 50–1*G*). Dorsal, ventral, and midlateral incisions in the vagina are avoided to prevent damage to the rectum, urinary bladder, and uterine branch of the urogenital artery, respectively.[3, 10, 11] Blunt scissors can be used to penetrate the peritoneum if the initial scalpel incision is not deep enough. The stab incision is gradually enlarged by stretching with the fingers until the entire hand can be passed into the abdomen.

The ovaries are identified by turning the hand ventrally, grasping the uterus, and following the horns to each ovary. To anesthetize the ovarian pedicles, several gauze sponges soaked in mepivacaine hydrochloride are tied together with a 36-inch length of umbilical tape, carried into the abdomen, and placed around each ovarian pedicle for 2 minutes. The end of the umbilical tape is left outside the vagina to enable the surgeon to retrieve the sponges if they are dropped in the abdomen. The chain écraseur is carried into the abdomen with the barrel of the écraseur next to the inside of the wrist and the chain loop around all but one finger (see Fig. 50–1*G*). The ovary is located, and the loop of the chain is placed over the ovary and around the pedicle (Fig. 50–1*H*). The chain is closed slowly until it is snugly around the pedicle and the surgeon checks to be certain no other abdominal structures are within the chain loop. The chain loop is then drawn into the barrel of the écraseur using the ratcheting handle mechanism to simultaneously crush and sever the ovarian pedicle. The surgeon should hold onto the ovary, and the handler at the head of the horse should be informed that some discomfort to the horse may occur. Some surgeons recommend closure of the chain loop over a 4- or 5-minute period to aid hemostasis. In our opinion, slow closure may prolong discomfort and is probably unnecessary for hemostasis.[10] We recommend steady closure over a 30- to 60-second period. Once the chain loop has been completely closed and withdrawn into the barrel of the écraseur, the écraseur and ovary are removed from the abdomen simultaneously. Sometimes fascia around the ovary will have to be torn to remove the ovary. Care is taken to pass the hand and écraseur under the small colon and mesocolon. The procedure is repeated to remove the opposite ovary. Severe hemorrhage from the ovarian pedicle is unlikely but, if present, should be managed by conservative treatment or by laparotomy and ligation. A second application of the écraseur to crush the pedicle is not recommended.[10]

The vaginal incision is usually not sutured, although some surgeons close the defect with several stitches using absorbable suture material. A Caslick's procedure is done to prevent pneumovagina and secondary abdominal contamination. Intraoperative complications include laceration of the rectum or bladder, hemorrhage from the ovarian pedicles, and inadvertent removal of mesocolon, small colon, or other abdominal viscera. These complications may be fatal. Incomplete anesthesia of the ovarian pedicle may cause the mare to buck, lunge, or go down in the stocks, thus risking injury to the patient and the surgeon and damage to the instrument.

[f]Carbocaine V, The Upjohn Co., Kalamazoo, MI.

Figure 50–1. *Continued*



Postoperative Management

Systemic antibiotics are continued for 5 days. Analgesics are administered as needed. The mare should be confined to a box stall and fed a normal ration after sedation has worn off. Controlled hand walking can be done daily. Some surgeons recommend cross-tying mares after surgery to discourage recumbency in an attempt to reduce the occurrence of eventration through the vaginal incision.[3, 12] Postoperative eventration is rare, and other surgeons do not routinely tie mares postoperatively.[10, 11] Vaginal incisions contract quickly and are generally healed in 14 days. Training can resume thereafter.

Other postoperative complications include colic, continued hemorrhage, and peritonitis. These complications are uncommon. Bilateral ovariectomy for elimination of estrous behavior is not always effective. In one study, estrous behavior continued to some extent in 35% of ovariectomized horses but was judged to be objectionable to owners in only 9%.[13] Ovariectomy may not cure horses with severe nymphomania because the problem may be caused by sources other than the ovary.[12]

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chapter 51

Cesarean Section

The second stage of labor in mares is short, and dystocia, although uncommon, requires prompt assistance. A delay in parturition is often fatal to the foal and may decrease the mare's subsequent fertility. Fetal causes of dystocia include large foal size, abnormal fetal posture, presentation, or position, and deformities of the fetus such as arthrogryposis, fetal monsters, and hydrocephalus.[1,2] The most common causes of dystocia in mares are fetal malposition and fetal deformities.[1] Experienced veterinarians can manage most of these dystocias by mutation, traction, and, when the foal is dead, partial fetotomy. Maternal causes of dystocia that are indications for a cesarean section include pelvic abnormalities caused by fractures, cervical strictures, uterine torsion, and uterine rupture.[1,2] Elective cesarean sections may be performed to obtain gnotobiotic foals and when pre-existing conditions in the mare that will prevent normal parturition have been recognized prepartum.

Cesarean section is indicated when assisted delivery of a live foal cannot be done expediently.[3] When anticipated delivery of a live foal cannot be accomplished within 15 minutes in a standing mare, induction of general anesthesia followed by controlled vaginal manipulation or cesarean section should be considered.[4] Live foals too large for vaginal delivery and foals in transverse presentation are best delivered surgically. Cesarean section is also indicated for removal of malpositioned or anomalous dead foals that cannot be mutated and delivered vaginally and when vaginal removal of dead foals would result in undue risk to the life or future reproductive capabilities of the mare. When a fetotomy may require more than two cuts, a cesarean section is recommended.[3] Additional fetotomy cuts generally result in excessive trauma to the reproductive tract of the mare and reduced fertility.

The goals of a cesarean section should be to obtain a live foal and preserve the life and fertility of the mare. Cesarean section on mares with live foals must be done expediently. Foal survival after 40 minutes from onset of the second stage of labor is poor. Successful surgery requires a team that can quickly anesthetize the horse, perform the cesarean section, and provide immediate care to the newborn foal. Delivery of a live foal by cesarean section is not common when the mare with dystocia is not near surgical facilities. The expediency of cesarean section in a mare with a dead foal is less critical but should proceed in an urgent manner. The surgical procedure of cesarean section on a mare with a live or dead foal is the same.

There are numerous surgical approaches to cesarean section in the mare, including the paramedian, paracostal, vertical flank, caudal ventral midline, and low oblique flank. The low oblique flank approach, also termed the *Marcenac approach,* is performed with the mare anesthetized and positioned in right lateral recumbency. This approach is popular in Europe.[5,6] The caudal ventral midline incision is familiar to most North American surgeons and is commonly used for cesarean section.[5] This incision can be made rapidly, incisional bleeding is minimal, the incision can be lengthened when necessary, and closure is generally secure.[4] The caudal ventral midline approach to cesarean section is the standard in North America and is described in this chapter.

Anesthesia, Positioning, and Surgical Preparation

Anesthetics given to the mare cross the placenta and affect the foal. Various methods have been proposed to decrease the anesthetic effects on the foal. Halothane may increase uterine bleeding. However, the anesthetic regimen is not as important as rapid induction of anesthesia, positioning of the mare, and delivery of the foal. A light plane of anesthesia should be maintained, and the mare should be maximally oxygenated. Foals are usually not clinically anesthetized when delivered within 20 minutes of onset of anesthesia.[7] Perioperative antibiotics are indicated, particularly when the foal is dead and contamination of the caudal reproductive tract has occurred during attempts at manipulation, reposition, and vaginal delivery. We recommend penicillin G potassium, 22,000 U/kg, and gentamicin sulfate, 6.6 mg/kg, as an intravenous bolus before surgery. The potassium penicillin can be administered again within 4 hours of completion of surgery.

The tail of the mare is wrapped. The surgical team is assembled and the mare anesthetized. The team should consist of a surgeon, assistant surgeon, anesthetist, and unscrubbed assistant. Sometimes it is possible to mutate and deliver malpositioned or malpostured foals once the mare has been anesthetized and posi-

tioned in dorsal recumbency with the hindquarters elevated 3 to 4 feet off the ground.[4] This position is achieved by hobbling the rear pasterns and using a hoist. Positioning the anesthetized mare with the hindquarters elevated results in a relaxed uterus in a nonstraining mare, with gravity assisting the repulsion of the fetus into the uterus. If the fetus can be positioned correctly, the hindquarters of the mare are lowered and the fetus is extracted. This procedure is successful in 60 to 70% of the difficult dystocias resulting from malposture.[4]

During the vaginal obstetric manipulation, the ventral abdomen of the mare should be surgically prepared for cesarean section by removing the hair with clippers and scrubbing. Vaginal obstetric manipulation should not exceed 6 to 8 minutes when the foal is alive. When it is unsuccessful, the mare is immediately hoisted onto the surgical table for surgery. The mare is positioned on the operating table in dorsolateral recumbency with the abdomen rotated 20° toward the surgeon when possible. Rotation of the ventral abdomen to one side allows the surgeon to exteriorize the uterus and the foal more easily, making it less difficult to keep contaminated uterine fluids out of the abdominal cavity during hysterotomy. Also, it may decrease pressure on the caudal vena cava from the gravid uterus. Adequate padding of the mare is essential. A final surgical scrub of the ventral abdomen is performed.

Surgery

The surgeon and assistant surgeon should double glove. The mare is draped for a caudal ventral midline laparotomy, and a 35- to 40-cm-long ventral midline incision is made in a craniad direction starting just cranial to the udder. Ventral midline laparotomy is described in Chapter 16. On entering the abdomen, the gravid horn is identified and the position of the uterus determined. Uterine torsion is corrected when possible before the gravid horn is elevated and exteriorized. When correction of the torsion is difficult or the uterus is edematous and friable, the foal should be removed first. The gravid horn is elevated and exteriorized through the incision. The exteriorized horn is stabilized by the assistant surgeon grasping fetal limbs through the uterus. When the foal is in anterior presentation, the hind limbs are grasped. When the foal is in posterior presentation, the forelimbs are grasped and the head and neck are manipulated to a position between the forelimbs in the exteriorized section of uterus. Sterile towels and impervious drapes are placed around the exteriorized uterus to isolate it from the abdominal incision, abdominal cavity, and underlying drapes. The assistant surgeon should grasp the uterus next to each end of the intended incision.

A scalpel blade is used to make an incision through the uterus and chorioallantois over the greater curvature of the gravid horn. Hemorrhage may be profuse. The surgeon should act quickly to remove the fetus, after which hemorrhage can be controlled. The length of the incision should be approximately the length of the foal's limb from the foot to the hock or carpus (Fig. 51–1*A*). The incision needs to be long enough to avoid tearing of the uterus during extraction of the foal. Generally, the incision will be slightly longer when the foal is in posterior presentation.[5] Scissors are used to incise the amnion and expose the limbs of the fetus. The surgeon should grasp the limbs, attach sterile obstetric chains, and pull the limbs and fetus up and out of the uterus. The chains are passed to an unscrubbed assistant, who continues to pull up on the chains to assist the surgeon in extracting the fetus. The surgeon lifts and guides the fetus as the assistant surgeon stabilizes the uterus to prevent it from slipping out of the sterile field or back into the abdomen as the foal is extracted (Fig. 51–1*B*). For large foals, an overhead rope or hoist can be attached to the chains and used in place of the unscrubbed assistant to lift the foal up in a slow, controlled motion as the surgeon guides the foal out of the uterus.

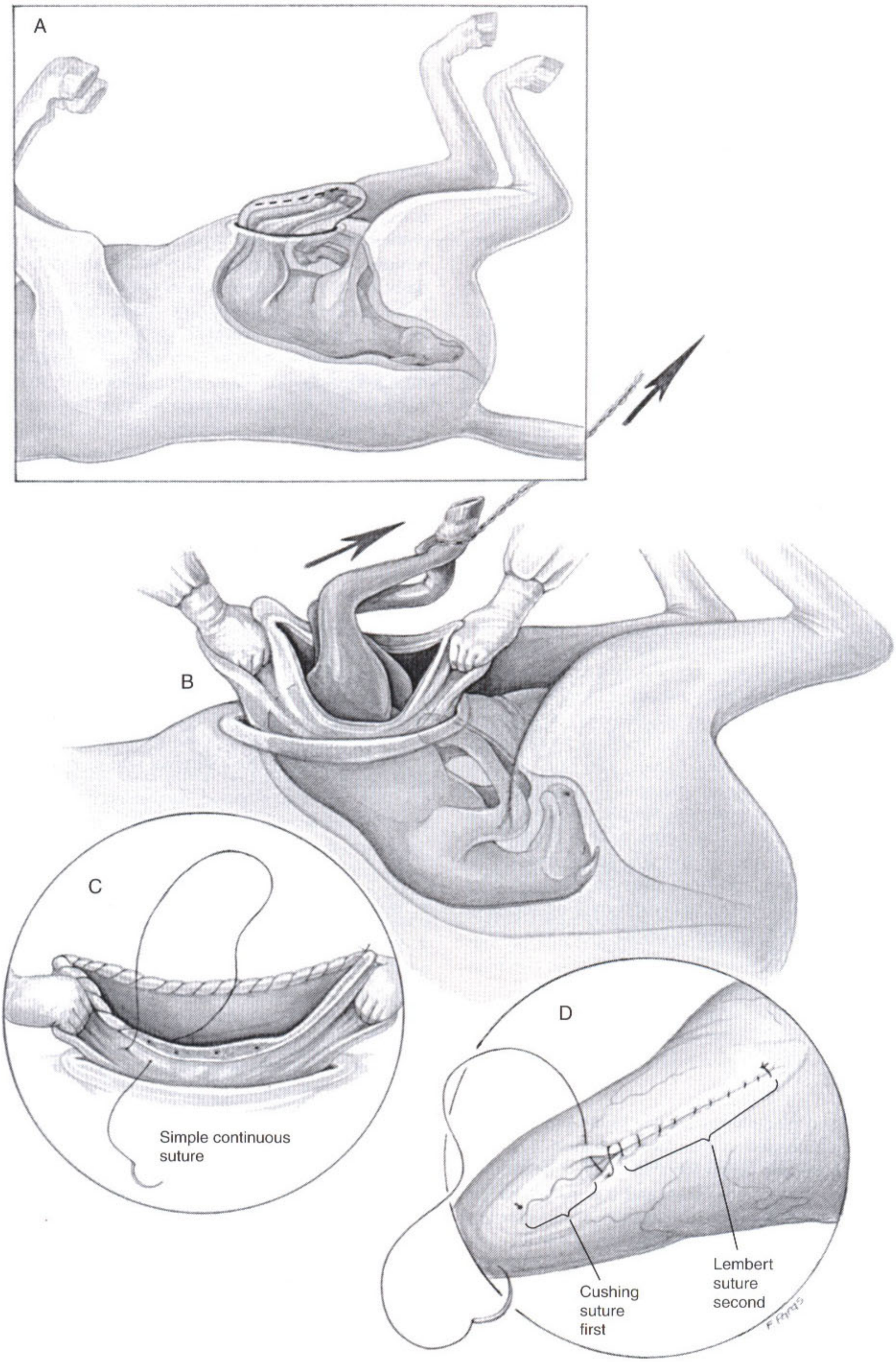
The foal is placed beside the mare for 2 to 3 minutes until pulsations of the umbilical artery decrease. However, some surgeons consider this procedure unnecessary.[4, 8] The nasal and oral mucus is removed from the foal by lowering the head and suctioning. The umbilical cord is separated by placing traction on the cord 5 cm from the umbilicus. If umbilical hemorrhage persists, the umbilical cord can be clamped next to the foal or ligated. Bleeding from the uterine end of the umbilical cord can be controlled with a knot in the cord. The foal is removed from the surgical field. An assistant should attend to the medical needs of a live foal. Assisted ventilation with 100% oxygen may be necessary in foals depressed from anesthesia.

The uterus should be kept exteriorized and positioned so that spilled uterine fluids drain out of the surgical field and not back into the abdominal cavity. Suction is used to remove residual uterine fluids. The placenta is removed if it can be easily separated from the uterus. Otherwise, the chorioallantois is separated from the incised edges of the uterus for a distance of 3 to 4 cm. It is important to prevent incorporation of the placenta in the uterine closure, thus contributing to a retained placenta after surgery. We control hemorrhage from the myometrial and subendometrial vessels by placing a simple continuous suture pattern through the full thickness of the uterus and over the incised edges (Fig. 51–1*C*). This hemostatic suture should be placed tightly using a no. 1 absorbable suture material. We prefer polyglactin 910[a] or polyglycolic acid[b] suture material. The assistant surgeon stabilizes the uterus by

[a]Vicryl, Ethicon, Inc., Somerville, NJ.

[b]Dexon, Davis & Geck, Inc., American Cyanamid Co., Manati, PR.

Figure 51–1.


A
B
C
Simple continuous suture
D
Cushing suture first
Lembert suture second

grasping it next to each end of the incision while the hemostatic suture is placed. This hemostatic suture should dramatically decrease intraoperative hemorrhage. Also it should decrease postoperative bleeding into the uterus, which has been reported to be a significant cause of death in mares after cesarean section.[6] One study questions the effectiveness of this hemostatic suture, and the authors recommend that the first layer of uterine closure be a snug Lembert pattern modified to take full-thickness bites of the uterus.[9] Clots are removed, and the uterine incision is closed with a Cushing pattern using size 1 or 2 polydioxanone[c] suture material followed by a Lembert pattern using the same material (Fig. 51–1*D*). The exposed part of the uterus is thoroughly cleansed and irrigated with sterile saline. The impermeable drapes and wet towels are removed from the surgical field. The surgeon and assistant surgeon should remove the outer contaminated pair of gloves and inspect and palpate the entire uterus for uterine tears. When present, uterine tears should be debrided and closed with the same two-layer inverting suture technique used for closure of the hysterotomy incision. The uterus is replaced into the abdomen. Forty units of oxytocin are administered intravenously to stimulate uterine contraction and promote expulsion of the placenta.

The surgeon and assistant surgeon should change gloves. Gowns and drapes should also be changed if they are soaked by uterine fluids or if breaks in sterile technique have occurred during delivery of the foal. The ventral midline incision is closed in three layers: the linea alba, subcutaneous tissues, and skin. We use size 2 polydioxanone suture material in the linea alba placed in a simple interrupted, simple continuous, or far-near-near-far pattern. The suture pattern is based on personal preference and on the size of the mare. The subcutaneous tissues and linea alba are lavaged after the linea is closed. Closure of ventral midline incisions is described in more detail in Chapter 16.

Postoperative Care

Fluids and electrolytes should be administered to the mare when needed to maintain hydration. Systemic antibiotics should be given for 3 to 5 days, depending on the degree of contamination and trauma to the vagina, uterus, and abdominal viscera. A nonsteroidal anti-inflammatory drug should also be given for 3 to 5 days to decrease swelling and pain and counteract endotoxemia. Tetanus prophylaxis should be ensured.

[c]PDS II, Ethicon, Inc., Somerville, NJ.

Up to 50% of mares will have retained placentas after cesarean section.[5] In eight horses that underwent elective cesarean section, the mean time for passage of the placenta was 29 hours (range, 4.5–72 hours).[7] When the placenta has not passed by the time the mare recovers from general anesthesia, 50 to 100 U of oxytocin in 1 L of sterile electrolytes are administered over a 1-hour period. This dose can be repeated every 6 hours until the placenta passes. Intrauterine lavage with sterile saline followed by siphon can be used to remove uterine exudate. This procedure can be done daily for 3 to 5 days.[5] Mares should be exercised by hand walking four to six times daily or turned out into a small enclosure commencing the day after surgery.

In addition to retention of fetal membranes and intrauterine hemorrhage, complications in mares after cesarean section include postoperative ileus, postoperative anemia, shock, peritonitis, metritis, laminitis, incisional infections, and dehiscence. Mares should be examined daily and complications identified and treated as they occur. Fertility rates after cesarean section are decreased.[3, 4, 6] Fertility may be impaired by uterine adhesions, endometrial scar tissue, damage to other areas of the reproductive tract, and inability of the uterus to stretch and expand for a growing foal as a result of scar tissue.[4] Mares bred 1 year after cesarean section have improved fertility compared with those bred the same year.[5]

The prognosis for survival of mares after cesarean section is good. Fatal complications are rare after cesarean sections that are performed within 24 hours of dystocia. An 80 to 90% survival rate in mares has been reported.[5]

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chapter 52

Resection of Umbilical Cord Remnants

Bacteremia in foals, leading to complications such as septic physitis and septic arthritis, can arise from pulmonary, gastrointestinal, and umbilical portals of entry. When the umbilical cord structures (two umbilical arteries, the umbilical vein, and the urachus) fail to retract into the abdomen when the cord ruptures at birth, or when the cord stump fails to dry and atrophy, these patent remnants can become infected and abscessed. When neonatal septicemia becomes refractory to medical treatment alone and the foal sustains recurring febrile episodes and persistent joint involvement, particularly when the umbilicus is tender or discharging pus, surgical excision of the umbilical remnants should be considered.

Congenital patent urachus, with dribbling of urine from the umbilicus at birth, may occur in foals. Many of these patencies close uneventfully. Some foals with congenital patent urachus acquire secondary infection of the umbilical cord structures. Conversely, some foals with infected umbilical cord remnants may acquire a secondary patent urachus. Acquired patent urachus probably is caused by the extension of inflammation and necrosis from the thicker walled umbilical vein or umbilical arteries in addition to direct involvement of the urachus itself. These changes cause the urachus to open after an initial period of closure. The acquired patent urachus is another indication to consider surgical excision of the remnants.[1]

Clinical assessment of foals with infected umbilical cord remnants or patent urachus, with the selection of those cases that require surgery, is not always straightforward. Diagnostic imaging can be helpful. Ultrasonography of umbilical structures in clinically normal foals and in foals with umbilical remnant infections has been described.[2, 3] Normally the diameter of the umbilical vein is less than 1 cm and the diameter of the combined umbilical arteries and urachus less than 2 cm in foals up to 4 weeks of age. When the umbilical vein approaches 2 cm in diameter and the umbilical arteries and urachus approach 3 cm, they should be considered abnormal. Enlargement of these structures, coupled with other abnormal ultrasonographic findings (e.g., pockets of flocculent echogenic material), is highly suggestive of infection. Not all of these cases require surgery; however, the prognosis for refractory neonatal septicemia is poor. When a foal fails to respond to medical therapy, when the clinical course lingers, and when the physical status of the umbilicus and ultrasound findings are suggestive of infection, we intervene surgically and resect the umbilical cord remnants.

Anesthesia, Positioning, and Surgical Preparation

Fluid deficits and electrolyte imbalances should be corrected in foals with neonatal septicemia, and the foals should receive parenteral antibiotics before being subjected to anesthesia and surgery. Inhalation anesthesia is recommended because the umbilical remnant involvement is variable and surgery time may exceed 1

hour. The foal is positioned in dorsal recumbency and prepared for a ventral midline exploratory laparotomy centered on the umbilicus. The abdomen is clipped and prepared from the inguinal region to beyond the xiphoid cartilage of the sternum. The bladder in males is catheterized to reduce urine spillage when the urachus is resected. A patent urachus can be probed at this point to establish the depth and direction of involvement. Standard asepsis as described for exploratory laparotomy is mandatory (see Chapter 16).

Surgery

The umbilical stump is ligated or clamped to preclude spillage of pus or urine. A liberal ventral midline incision, up to 20 cm, is made just rostral to the prepuce or mammae forward to ellipse the umbilicus. If the umbilical vein is involved, the incision should be extended cranially to allow exposure of the vein. A liberal exposure aids retraction and the removal of all diseased tissue; the time and trauma of suturing a long incision are less than that of endeavoring to identify and remove diseased tissue with limited visualization and exposure. Because of possible adhesions in the region, the abdomen is entered through normal linea alba rostral to the umbilicus, and dissection is guided by intra-abdominal palpation as the umbilical stump is sharply dissected free. Because of their superficial, ventral location in the abdomen, the remnants are readily identified (Fig. 52–1*A* and *B*).

Initial dissection is focused on the bladder. A Balfour abdominal retractor[a] aids exposure, particularly if there are no assistants. Moist towels are used to isolate the bladder and umbilical cord remnants from the remaining abdominal contents. The umbilical arteries must be sharply dissected from the lateral ligaments of the bladder and ligated proximal to any inflammatory thickening or abscess (see Fig. 52–1*B*). This dissection can be deep in the caudal abdomen, approaching the confluence of the umbilical arteries with the iliac arteries. The proximal segments of the umbilical arteries can be patent, mandating secure ligatures. The smaller lateral branches of the internal pudendal arteries supplying the bladder, also located in the lateral ligaments adjacent to the bladder wall, must be preserved (see Fig. 52–1*B*). Accidental severing of these vessels causes unexpected, profuse hemorrhage that must be controlled for the safety of the patient.

The transition between the bladder apex and urachus is usually apparent. The bladder is stabilized with Babcock tissue forceps[b] and the urachus transected (Fig. 52–1*C*). The bladder apex is closed with a two-layer inverting suture pattern of size 2–0 polyglycolic acid.[c] Delayed-absorbable or nonabsorbable suture material is not recommended for fear of nidus formation. We use a Cushing pattern for the first layer oversewn with a Lembert pattern for the second layer (Fig. 52–1*D*). Alternatively, the bladder can be cross-clamped and the urachus transected followed by a Parker-Kerr oversew of the bladder.

The umbilical vein is ligated proximal to any disease, completing the resection and removal of the umbilical remnants (Fig. 52–1*C*). This can approach the caudal surface of the liver, requiring rostral extension of the laparotomy incision. Occasionally, the umbilical vein is diseased to the point of precluding ligation without risk of serious abdominal contamination. In such cases, the vein can be marsupialized to provide external drainage.[4] This is accomplished by first ligating the umbilical end of the vein and resecting the previously freed urachus and umbilical artery stumps. Then the umbilical vein is mobilized and passed through a separate 3-cm incision lateral to the midline incision (Fig. 52–1*E*). After suitable lavage of the abdominal cavity, the laparotomy incision is closed routinely. As a final step in the process of marsupialization, the umbilical vein is secured and sealed to the body wall with simple interrupted sutures of delayed-absorbable material[d] in the external sheath of the rectus abdominis, subcutaneous tissue, and skin. The umbilical vein is opened for drainage and lavage. Umbilical cord remnants are resected as a matter of course, even if normal, when exploratory laparotomy is performed for other reasons in young foals (e.g., ruptured bladder, intestinal obstruction or strangulation).

Postoperative Management

The postoperative care of these patients is focused on the neonatal septicemia. The resected tissues should be cultured and sensitivity tests used to determine specific antibiotic therapy. Fortunately, problems such as peritonitis and incisional infections are uncommon in these foals. We believe that excision of umbilical cord remnants should be considered for all foals that have persistent bacteremia or septicemia for which the source of infection is suspected to be the umbilicus or is unknown.

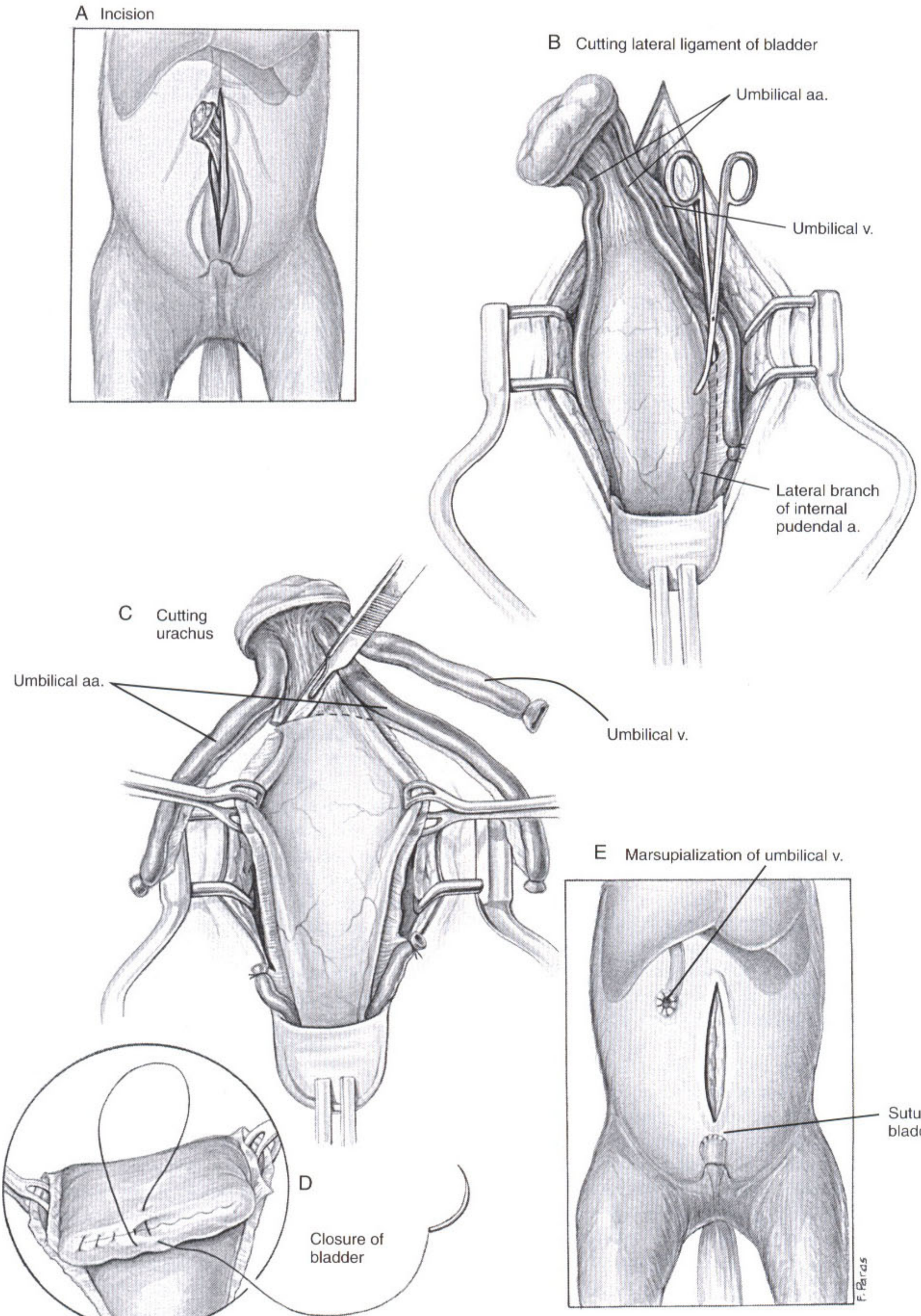
[a]Balfour abdominal retractor, Baxter Healthcare Corp., Round Lake, IL.

[b]Babcock tissue forceps, Baxter Healthcare Corp., Round Lake, IL.

[c]Dexon, Davis & Geck, Inc., American Cyanamid Co., Manati, PR.

[d]PDS II, Ethicon, Inc., Somerville, NJ.

Figure 52–1.


A Incision
B Cutting lateral ligament of bladder
Umbilical aa.
Umbilical v.
Lateral branch of internal pudendal a.
C Cutting urachus
Umbilical aa.
Umbilical v.
E Marsupialization of umbilical v.
Sutured bladder
D
Closure of bladder
F. Pardas

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chapter 53

Ruptured Urinary Bladder Repair

Rupture of the urinary bladder occurs sporadically in foals and is more prevalent in males than females. Ruptures in newborn foals are believed to be caused by extreme pressure on the bladder during parturition.[1,2] The bladder most often ruptures at the dorsal or craniodorsal aspect, which has a thinner wall than other areas.[3] Uroperitoneum results in clinical signs and metabolic disturbances in foals. The signs are usually noted 1 to 5 days after rupture and include depression, anorexia, straining, and mild colic.[4] These signs may be similar to those caused by meconium impactions. Tachypnea, tachycardia, and fluid distention of the abdomen are usually present. Foals may void streams of urine, but increased frequency and decreased volume of micturition occur.

The diagnosis of ruptured bladder is made on the basis of history, clinical signs, and physical examination. Foals usually have marked hyponatremia, hypochloremia, and hyperkalemia. Metabolic acidosis is common. The creatinine level in the fluid obtained from the abdominal cavity is usually two or more times greater than the serum level because of the presence of urine. The instillation of a sterile dye solution of fluorescein or methylene blue into the bladder via catheter with subsequent detection of the dye in the abdominal fluid confirms a tear in the bladder. Contrast cystography may also be used to evaluate the bladder for tears. This technique may aid in determining the size and location of the tear. Cystoscopy of the bladder in female foals is possible with most endoscopes and is useful in confirming bladder ruptures. Endoscopy of colts requires a long, small-diameter endoscope.

Small tears may heal spontaneously.[5] Foals with very small dorsal bladder tears may be treated with abdominal drainage, correction of metabolic disturbances, medical support, and closed catheter drainage of the bladder until the tears heal.[5] Most foals will require surgical repair of the ruptured bladder. Before surgery, metabolic disturbances should be corrected to reduce the risk of cardiac arrhythmias during general anesthesia. Metabolic abnormalities are often marked because of the frequent delay in onset of clinical signs. Normotonic or hypertonic saline is indicated to correct hyponatremia and hypochloremia. Fluids should not contain potassium. The uroperitoneum should be drained before surgery using a teat cannula, Pezzer drain[a], or sump drain. Surgical repair of the ruptured bladder is not an emergency; stabilization of metabolic disturbances is an emergency. All foals should be thoroughly examined for concurrent medical problems such as septicemia, failure of passive transfer of immunoglobulins, pneumonia, and enteritis. These problems should be treated before proceeding with surgical correction of the ruptured bladder.

Anesthesia, Positioning, and Surgical Preparation

Perioperative antibiotics should be administered to all foals. General anesthesia is recommended, and when inhalation anesthetics are available, induction of anesthesia can be performed by masking. Once anesthetized, the foal is placed in dorsal recumbency on a heating pad, a warm water–filled mattress, or a foam mattress to reduce the loss of body heat and prevent hypothermia. In male foals, a sterile rubber 14-gauge French catheter[b] or other suitable soft urinary catheter is aseptically inserted into the bladder, and the penis and catheter are pulled to one side with the penis gently extended to eliminate the preputial cavity. This maneuver will allow adequate surgical preparation of the prepuce. Female foals are also catheterized with soft rubber catheters. Hair is removed with clippers, and the surgical scrub is performed from the xiphoid to the inguinal rings and laterally as far as the folds of the flanks. Surgical preparation of the prepuce in males should be performed because the surgeon occasionally needs to extend the incision caudally along the side of the prepuce for additional exposure of the bladder. Routine surgical draping is performed. The drapes should be positioned in male foals to allow caudal extension of the incision along the side of the prepuce when necessary. Suction for removal of abdominal fluids should be available.

[a]Pezzer drain, Bard Urological Division, Covington, GA.
[b]Rubber catheter, Sherwood Davis & Geck, St. Louis, MO.

Surgery

In young foals with rupture of the bladder, the umbilical cord remnants are present, and the initial dissection is identical to that described for resection of umbilical cord remnants in Chapter 52. A ventral midline skin incision 15 to 20 cm long is made from just rostral to the prepuce or mammae forward to ellipse the umbilicus and continue on midline (Fig. 53–1*A*). The abdomen is entered on midline through the linea alba rostral to the umbilicus, and the incision is continued caudally around the urachal stump to free the stump from the body wall. The umbilical vein and arteries are ligated and transected, and the bladder is exposed by traction on the umbilical remnants (Fig. 53–1*B*). Examination of the bladder will allow determination of the location and size of the tear. More than one tear may be present.[1] Tears that occur in the dorsal or craniodorsal aspect of the bladder will be easily exteriorized. Some tears extending caudally toward the neck of the bladder are not easily exteriorized. For caudal tears, exposure in males can be improved by extending the skin incision along the side of the prepuce, reflecting the penis and prepuce laterally, and extending the incision through the linea alba on the ventral midline. Rarely, the tear is not readily identified. Sterile saline solution can be injected through the urethral catheter to distend the bladder and cause leakage. The wall of the bladder may be friable, discolored, and of compromised strength.

In many foals, the tear is small and close to the apex of the bladder near its junction with the urachus (see Fig. 53–1*B*). The urachus and the torn area of the bladder can be resected as a single procedure. The bladder is stabilized with Babcock tissue forceps[c] or stay sutures and transected so the tear is completely removed. The bladder is closed with a two-layer inverting suture pattern using 2–0 polyglycolic acid[d] or polyglactin 910.[e] We use a Cushing pattern as the first layer and a continuous Lembert pattern in the second layer. Atraumatic taper-point needles should be used, and sutures should not penetrate the mucosa of the bladder. In other foals, tears are not adjacent to the apex of the bladder, or they are oriented in a longitudinal direction. The edges of these tears should be carefully debrided using scissors and leaving as much healthy bladder as possible. The tear is closed with a two-layer inverting suture pattern technique or with a simple continuous pattern followed by an inverting pattern using size 2–0 polyglycolic acid or polyglactin 910 suture material (Fig. 53–1*C*). After the tear has been repaired, the urachus is transected and removed as described in Chapter 52, and the bladder is closed. The urachus and excised edges of the torn bladder should be submitted for culture and histopathology in all septic foals.

The bladder should be distended with saline and compressed to check for any leakage. Any leaks that are found should be repaired. The peritoneal cavity should be lavaged with sterile balanced polyionic fluids when fibrin or septic peritonitis is present or the surgery has been prolonged. Suction should be used to remove residual urine and lavage fluids. Before closure, the peritoneal cavity should be inspected for additional abnormalities. The body wall is closed with a simple continuous suture pattern using size 1 polydioxanone[f] suture material. Subcutaneous tissues are closed with a simple continuous pattern using 2–0 synthetic absorbable suture material, and the skin is closed with nonabsorbable monofilament suture material in the pattern of the surgeon's choice or with staples.

Postoperative Management

Antibiotics are continued in the postoperative period in foals that have septicemia, peritonitis, infected umbilical remnants, or other infections and in foals with failure of passive transfer of immunoglobulins. We administer perioperative antibiotics but do not administer antibiotics in the postoperative period to foals with uncomplicated tears. Some surgeons place a soft urinary catheter in the bladder for 24 to 48 hours to facilitate drainage.[1] We do not maintain a urinary catheter postoperatively in foals with satisfactory closure of healthy bladder tissue. The use of a drain in foals with compromised bladder tissue for which the closure of torn edges is not secure is debatable. Although the catheter may cause trauma to the suture line, closed catheter drainage of the bladder may be beneficial by reducing pressure within the bladder.

Complications

During surgery, cardiac arrhythmias are common as a result of the metabolic and electrolyte disturbances and acid-base imbalances. These should be corrected before surgery, with careful attention to anesthesia during surgery. Incisional edema is common. Incisional infections and incisional hernias occur infrequently. Postoperative peritonitis is not common but has been reported.[1] Failure of the cystorrhaphy with leakage of urine from the bladder is a common postoperative complication. In one study, leakage occurred in 6 of 18 foals undergoing surgery.[1] Leakage may occur because the bladder is weak and ischemic around the tear.

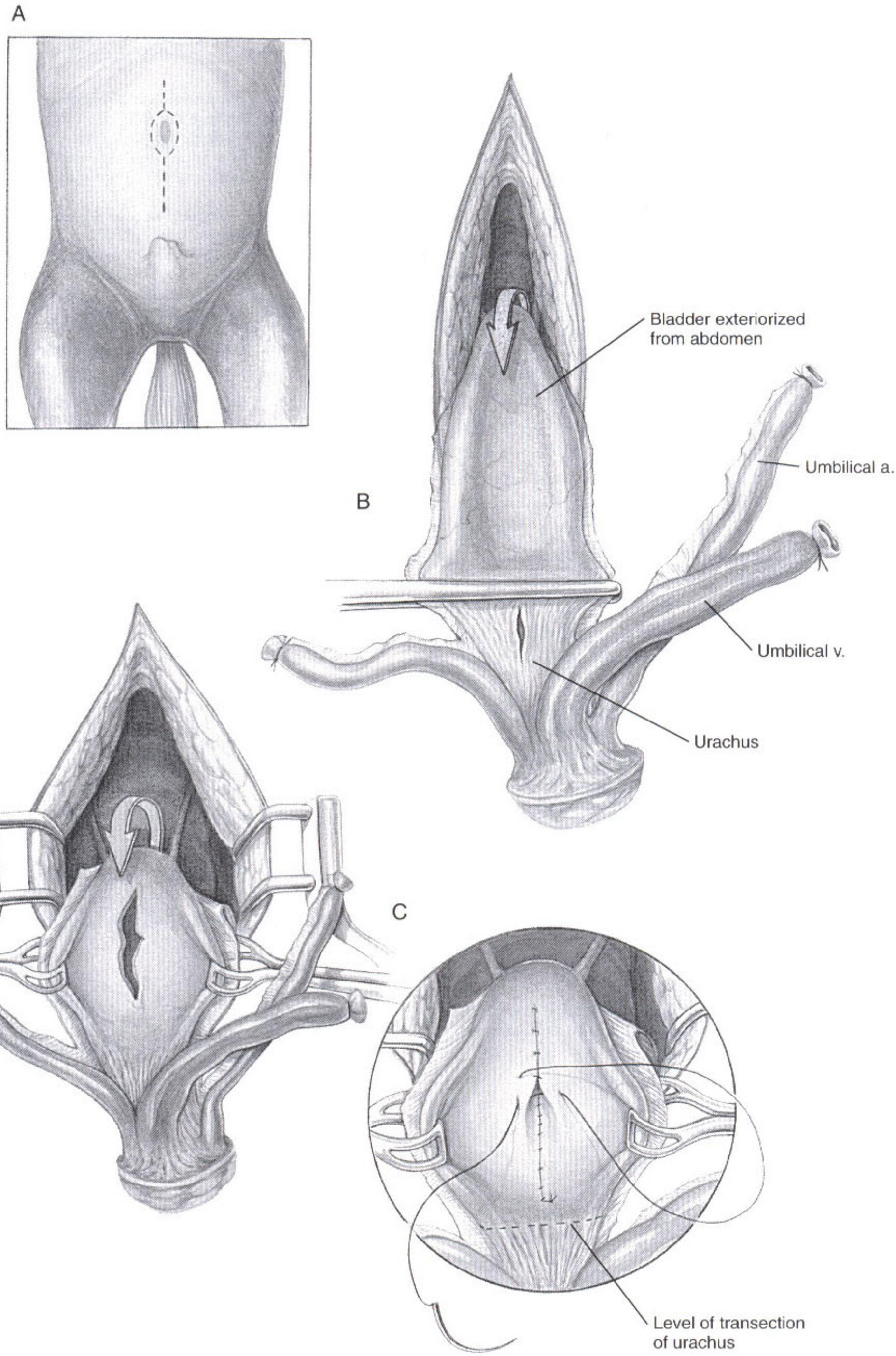
[c]Babcock tissue forceps, Baxter Healthcare Corp., Round Lake, IL.

[d]Dexon, Davis & Geck, Inc., American Cyanamid Co., Manati, PR.

[e]Vicryl, Ethicon, Inc., Somerville, NJ.

[f]PDS II, Ethicon, Inc., Somerville, NJ.

Figure 53–1.


A
B
Bladder exteriorized from abdomen
Umbilical a.
Umbilical v.
Urachus
C
Level of transection of urachus

Intraoperative debridement of damaged or necrotic bladder and suture of healthy tissue will reduce this complication. Postoperative necrosis of a large part of the bladder has been reported and has occurred in our hospital.[1] Foals with this complication require amputation of the necrotic bladder. A thorough physical examination, supported by laboratory data, and an abdominocentesis should be done on all foals that do not make an uneventful rapid recovery after the initial surgery.

Prognosis

The prognosis for foals with uncomplicated bladder ruptures that are treated in a timely manner is good.[6] Delay in treatment, presence of severe metabolic abnormalities, compromised bladder wall, and concurrent complications in foals with ruptured bladders make the prognosis guarded to fair.

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chapter 54

Perineal Urethrotomy and Removal of Cystic Calculi

Perineal urethrotomy is indicated for treatment of urethral and cystic calculi in male horses. When urethral calculi are present, perineal urethrotomy can be used for temporary bypass of the obstruction. Urethral calculi may be manipulated and removed by urinary catheters and forceps inserted through the urethrotomy incision. Perineal urethrotomy is an alternative procedure to suprapubic laparocystidotomy for removal of cystic calculi.[1–3] There are several advantages to perineal urethrotomy: the surgery is performed on the standing horse, there is little risk of peritonitis, horses can be returned to work in 2 or 3 weeks, and the cost is less than for suprapubic laparocystidotomy.[4] Disadvantages include a high rate of recurrence of calculi, the need for a lithotrite or custom-made chisels, trauma to the bladder and urethra, and difficult surgery when large calculi need to be crushed before removal.[4] Perineal urethrotomy for removal of cystic calculi is easier when the calculi are small and they can be removed intact. Such calculi are generally 5 cm or less in diameter. Intractable horses are not good candidates for this standing surgery.

Anesthesia, Positioning, and Surgical Preparation

When performing perineal urethrotomy, we prefer to put horses in stocks. Horses are sedated with detomidine or a xylazine hydrochloride–butorphanol combination given intravenously. The tail is wrapped. Regional analgesia of the surgical site is achieved by epidural analgesia using 0.17 mg/kg body weight of 10% xylazine hydrochloride and 0.22 mg/kg body weight of 2% lidocaine hydrochloride or mepivacaine hydrochloride diluted to a total volume of 10 ml. This combination of drugs provides a rapid onset and long duration of analgesia and produces no ataxia.[5] After epidural injection, the rectum is evacuated of feces, and the tail is tied to one side. The surgical site is surgically prepared. Hair is removed from a wide area of the ischial region. In horses with cystic calculi, a sterile rubber or plastic stallion catheter 6 to 10 mm in diameter is inserted aseptically into the bladder to serve as a landmark for identification of the urethra during surgery.

Long forceps for grasping the cystic calculi are necessary. Suitable grasping instruments include Knowles cervical forceps,[a] a lithotrite, Hobday obstetric forceps,[b] and long sponge forceps. A lithotrite will be necessary if the stone must be crushed before removal (Fig. 54–1). Alternatively, large custom-made chisels can be used to break the calculi. We are unaware of a commercial source for a lithotrite or for chisels, and our instruments were custom-made by a local machine shop.

[a]Knowles cervical forceps, Sklar, West Chester, PA.
[b]Hobday OB forceps, Jorgensen Laboratories, Inc., Loveland, CO.

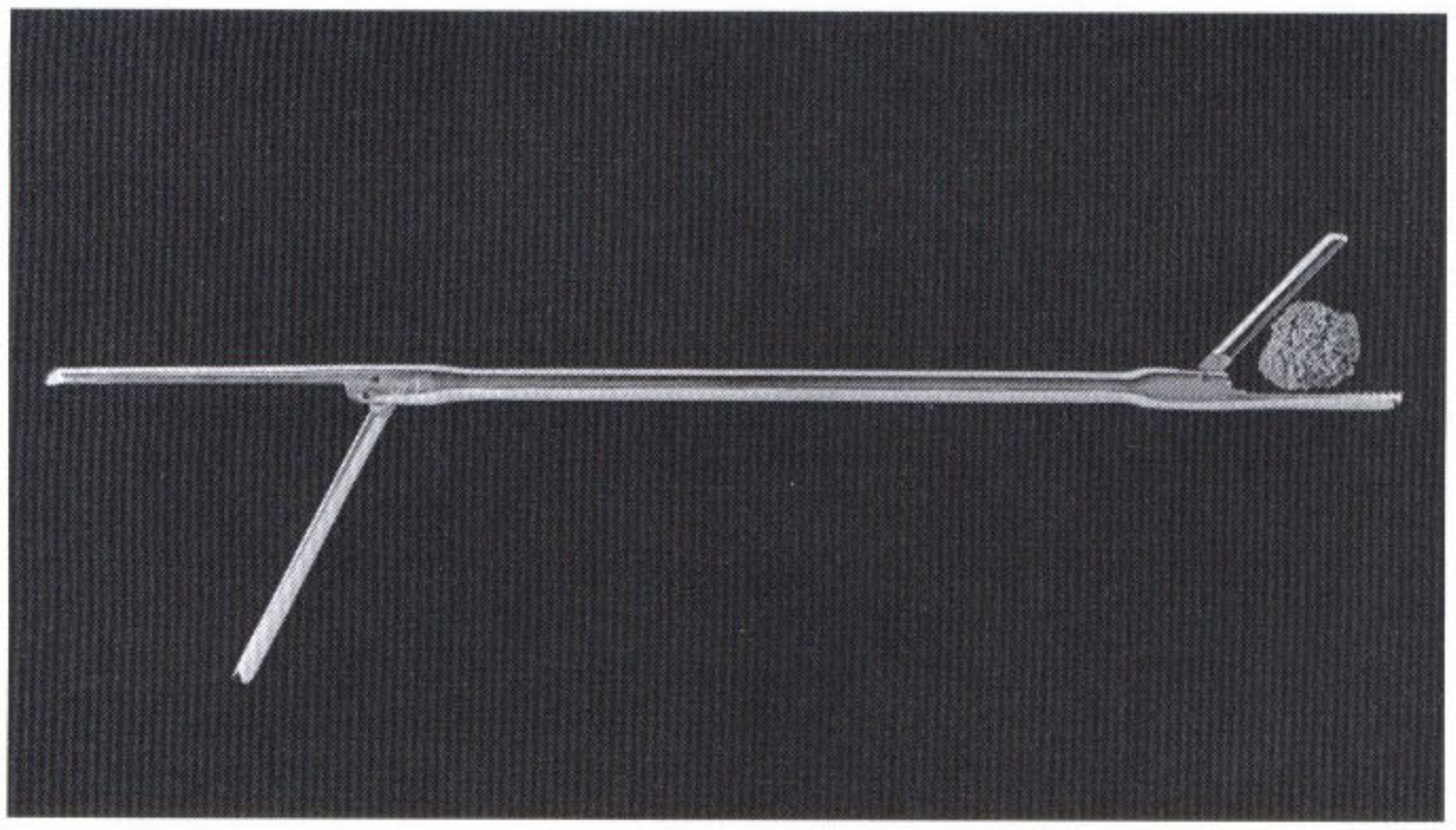


Figure 54–1.

A custom-made lithotrite for grasping and crushing cystic calculi.

Surgery

An 8-cm midline skin incision is made starting 4 to 6 cm below the anal sphincter and extending distally (Fig. 54–2*A*). The distal end of the incision extends to the level of the ischial arch. The incision is continued on midline between the paired retractor penis muscles (Fig. 54–2*B*). At this point, the catheter in the urethra should be easily palpated to aid identification of the urethra. With a scalpel blade the incision is continued on midline through the bulbospongiosus muscle, the corpus spongiosum urethra, and the urethral mucosa. The surgeon should incise directly down to the catheter (Fig. 54–2*C*). Some hemorrhage will be encountered. Generally, the hemorrhage will subside spontaneously or after gentle digital pressure with gauze sponges. The catheter is removed, and the incision in the urethra is extended with scissors so that it is centered over the horizontal part of the pelvic urethra, thus allowing insertion of straight instruments directly into the bladder (Fig. 54–2*D*).

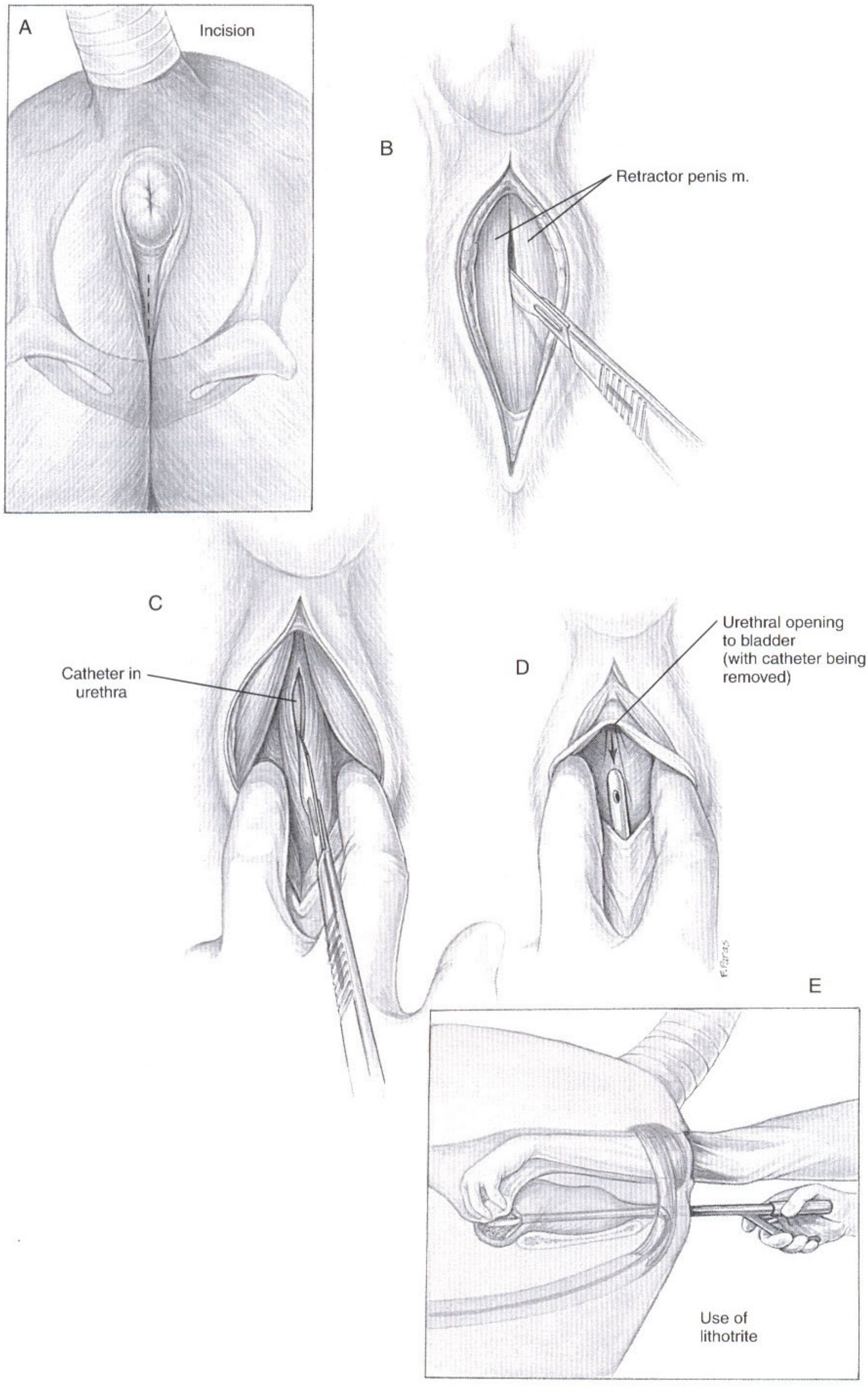
For removal of cystic calculi, an arm is inserted into the rectum to grasp the bladder and manipulate the calculus into the neck of the bladder. Small stones may be grasped with forceps or a lithotrite for removal. Once the calculus is grasped, the forceps should be twisted 360° to ensure that the bladder mucosa has not been entrapped in the forceps. Some calculi will be attached to the bladder mucosa and will need to be manipulated to free them. Extraction is aided by copious lubrication with sterile obstetric jelly and gentle traction. Gentle manipulation and traction should be used to allow the pelvic urethra to dilate. Stones up to 5 cm in diameter can usually be removed by extraction. Larger stones must be crushed into smaller fragments with a lithotrite or broken with a chisel and then removed. The lithotrite is inserted into the bladder, and the calculus is manipulated rectally into the open jaws of the instrument which are then closed (Fig. 54–2*E*). The surgeon ensures that the mucosa is not entrapped by twisting the lithotrite 360° while palpating the bladder per rectum. To crush the stone, the jaws of the lithotrite are completely closed. This may require considerable force on the handles. Once crushed, the fragments of the calculus are removed using copious lubrication of the pelvic urethra.

The bladder should be flushed with several gallons of sterile saline to remove small fragments and debris.[4] A tube 20 to 40 mm in diameter is used for flushing. The bladder can be filled and drained by siphoning through the same tube or can be filled with one tube and drained with a second tube attached to a suction unit. We prefer the latter technique. The surgeon can assist bladder emptying by putting pressure on the bladder per rectum. The distal urethra should be flushed to remove debris, and the bladder can be evaluated endoscopically to determine whether all fragments have been removed.[4] The wound is left to heal by second intention.

Postoperative Management

The urethrotomy incision and surrounding area should be cleaned daily. Petroleum jelly or zinc oxide ointment can be applied to the skin of the hindquarters and hind limbs to avoid urine scalding. The bladder may be flushed once daily with 1 gallon of dilute antiseptic solution for 4 to 5 days. Healing is generally uncomplicated. The urethra is usually closed in 2 to 3 weeks, after which the horse can resume training.

Figure 54–2.


A
Incision
B
Retractor penis m.
C
Catheter in urethra
D
Urethral opening to bladder (with catheter being removed)
E
Use of lithotrite

Complications

Recurrence is the most common complication of cystic calculi removed by perineal urethrotomy. In one study, recurrence of calculi occurred in 7 of 15 horses after perineal urethrotomy.[1] Calculi may recur more frequently after perineal urethrotomy than after laparocystidotomy because small fragments of calculi may be left from the initial surgery to become a nidus for new calculus formation. Careful attention to removal of all fragments and debris after perineal urethrotomy should reduce the risk of recurrence. However, new calculi may form spontaneously in horses because the same factors that contributed to the formation of the first calculi may still be present. Postoperative urinary acidification has been attempted with numerous acidifiers, with little long-term success. Equine urine can be acidified only for short periods.[6] Other, infrequent complications from cystic calculi removal by perineal urethrotomy include rectal tear, perforation of the bladder, urethral trauma, scrotal swelling, fever and depression, tenesmus, and dysuria.[1]

Perineal urethrotomy for removal of cystic calculi is an alternative to laparocystidotomy when general anesthesia is not available, when keeping the costs low is important, when the calculi are small, and when a lithotrite or chisel is available to break up larger calculi.

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chapter 55

Suprapubic Laparocystidotomy

Cystic calculi are rare in the horse. They occur predominantly in older geldings, but stallions and mares can be affected as well.[1] All breeds can be affected. Formation and growth of urinary calculi involve the precipitation and accretion of crystals from the urine. In horses, they are composed of calcium carbonate in the form of calcite, with occasional other trace elements.[2] The alkaline urine favors precipitation of calcium carbonate in horses. Most calculi have rough, porous, granular nodules on the surface and tend to adhere to the bladder mucosa; less than 10% have smooth lobate surfaces. Blood in the urine is the most common complaint of owners of horses with cystic calculi. A loss in physical condition may have been noted. These horses may dribble urine; posture frequently to urinate; void small amounts of urine; demonstrate tenesmus, particularly after voiding; and relax the penis from the sheath for prolonged periods. Hematuria occurs toward the end of micturition and is especially evident after exercise. The hindlimbs can be stained with blood and urine.

Rectal palpation confirms the presence of a hard, well-defined mass within the bladder. Up to 10% of such cases have calculi in multiple locations within the urinary tract, suggesting the need for a complete examination, including ultrasonography of the ureters and kidneys.[1] Cystic calculi cause a traumatic cystitis, but deep-seated secondary infection is uncommon. These horses tend to have a small, constricted bladder with little residual urine. If bladder atony, with or without bacterial cystitis, is identified, lumbosacral neurologic disease should be suspected. Horses that cannot empty the bladder properly collect sandlike sediment that, after catheterization, can feel like a calculus on rectal palpation. Horses with neurologic disease are not candidates for surgery.

Both perineal urethrotomy and laparocystidotomy are used to remove cystic calculi from male horses. Perineal urethrotomy is traumatic to the urethra. It is a semiblind procedure that requires special instruments, is not useful for large calculi, and carries the risk of leaving a nidus for another bladder stone to form.[3] In the future, semi-invasive methods for calculi removal may become readily available,[4] but for now, large, granular calculi that are adherent to the bladder mucosa are best removed by laparocystidotomy.

Anesthesia, Positioning, and Surgical Preparation

Feed is withheld for 12 hours, and the rectum is emptied of feces just before anesthesia is induced. General inhalation anesthesia is necessary to perform a laparocystidotomy. The horse is positioned in dorsal recumbency. It is helpful to be able to lower the forequarters of the patient, permitting intestines to shift away from the pelvic region. The hair is clipped from the caudal abdomen and inguinal region, and the area is routinely prepared for aseptic abdominal surgery. A sterile urinary catheter is passed to the neck of the bladder, and the penis is extended and temporarily fixed to the side away from the intended incision site. Penicillin G potassium, 22,000 U/kg, is administered as an intravenous bolus both before the induction of anesthesia and within 6 hours of the completion of surgery. Penicillin is concentrated by the kidneys in the urine and, in the absence of bacterial cystitis with a known pathogen, is an excellent perioperative antibiotic for this surgery. In addition to suction and cautery, Balfour retractors[a] or comparable spreaders can aid exposure of the bladder. Impervious draping is helpful for maintaining asepsis.

Surgery

An 18- to 20-cm longitudinal paramedian skin incision, positioned cranial to the brim of the pelvis, is made immediately adjacent to the prepuce (Fig. 55–1*A*). The incision is extended through the preputial fat and fascia by a combination of sharp and blunt dissection to expose the external fascia of the rectus abdominis muscle. Lymphatic tissue and large veins are preserved. Vessels that inhibit exposure are double-ligated and divided. A 16-cm longitudinal incision, long enough to permit entry of the surgeon's hand, is made in the external rectus fascia just rostral to the prepubic tendon. The rectus abdominis muscle fibers are bluntly separated; some bleeding may occur when the inscriptiones tendineae are torn. The internal rectus fascia and peritoneum are incised, and excess peritoneal fluid is suctioned. Self-retaining retractors[a] may be useful, particularly when the bladder and calculus do not present readily to the incision, but the surgery can be performed without them. We prefer to protect the laparotomy incision with a plastic ring drape.[b]

The surgeon identifies and grasps the bladder and calculus with the full hand, fingers and thumb encircling the bladder distal to the calculus, and applies firm but gradual traction (Fig. 55–1*B*). With patient traction over several minutes, the bladder stretches and presents to the incision. Guy sutures of 1/8-inch umbilical tape are placed 2 cm apart in the full thickness of the wall of the apex of the bladder (see Fig. 55–1*B*). These sutures provide traction and positioning of the bladder for cystotomy. Guy sutures are less traumatic than tenaculum-type instruments, but if the sutures are placed superficially in the bladder wall or if too much traction is applied, they will tear out. Stretching and positioning the bladder for calculus removal require patience and persistence. Moistened hand towels are used to pack off the bladder. A longitudinal incision of sufficient length to deliver the calculus is made between the guy sutures in the apex and dorsal wall of the bladder. Fingers or a smooth instrument are used to peel the bladder mucosa from the calculus, which is then removed (Fig. 55–1*C*). Some crumbling of the calculus is inevitable. Remaining fragments are removed with sponge forceps, a moistened gauze sponge, and copious lavage and suction of the bladder.

Size 0 polyglycolic acid[c] on a swagged-on half-circle taper-point needle is used to suture the bladder using a two-layered closure. A simple continuous or Cushing pattern can be used in the mucosa, oversewn with a Lembert pattern as the second layer (Fig. 55–1*D*). The bladder wall is usually thickened, requiring judicious stitch placement to effect sealing of the incision and inversion of the serosal layer. Depending on the thickness, the Lembert sutures can be applied in either a continuous or an interrupted pattern. The sites of guy suture placement must be inverted with the Lembert sutures (see Fig. 55–1*D*). After the bladder is sutured and the towel packing removed, the incision site is lavaged. No effort is made to suture the peritoneum or deep fascia of the rectus muscle. Torn tags of rectus abdominis muscle are debrided. If the rectus muscle is noticeably thick and separated, three or four nonstrangulating, widely placed simple interrupted sutures of size 0 polydioxanone[d] can be used to approximate the muscle belly. The external rectus fascia is sutured with size 2 polydioxanone using an interrupted pattern. The subcutaneous preputial tissues are subjected to debridement and additional lavage and suction. Because of their fatty nature, these tissues can be traumatized by the extensive manipulation of this surgery. This final debridement and copious lavage helps to prevent incisional infection. These tissues are sutured in a fashion to obliterate space by tacking the preputial tissue to the abdominal tunic. If the prepuce is thick, two or three layers of sutures may be required. Skin closure is routine. No drains are required.

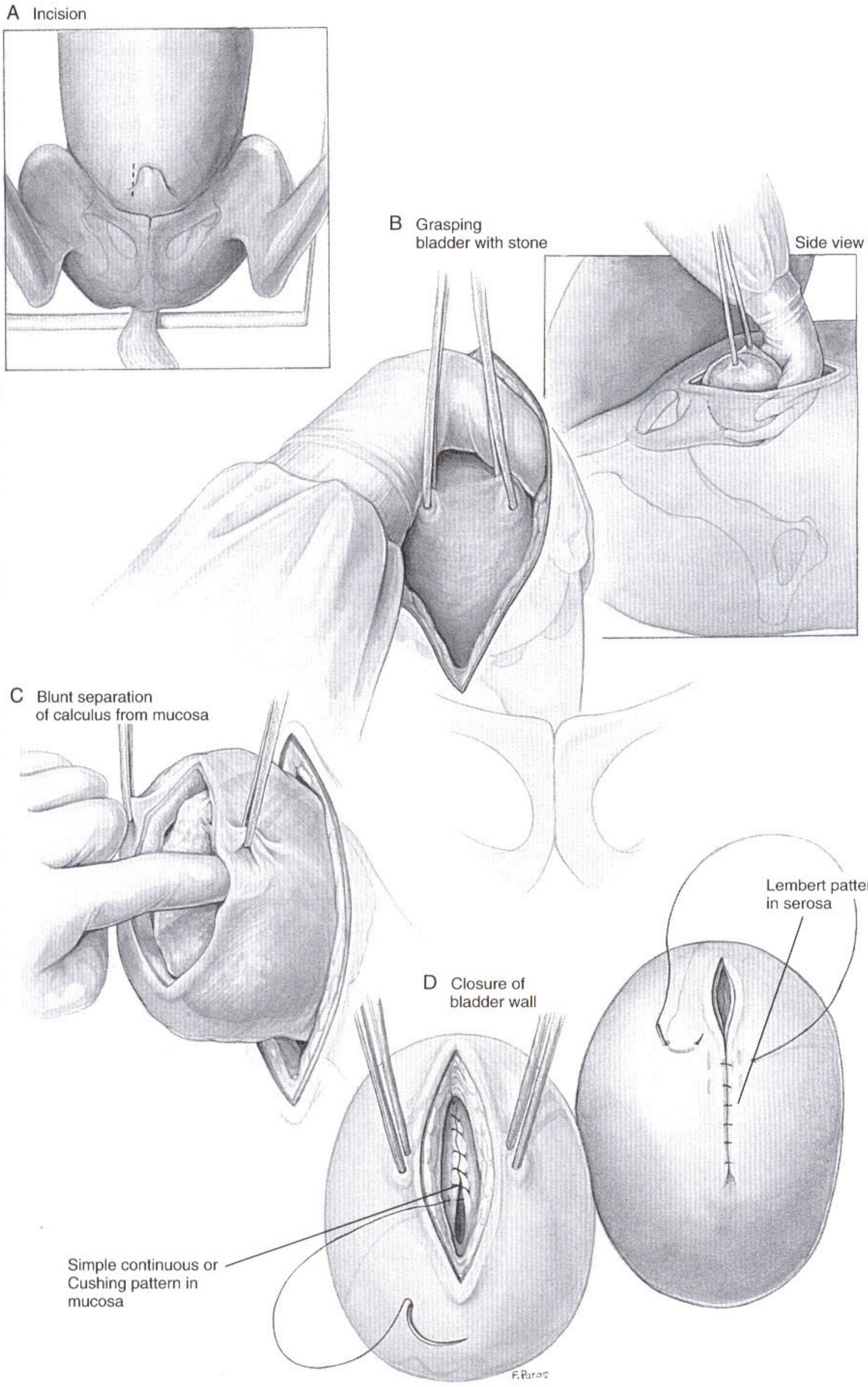
[a]Gibson-Balfour abdominal retractor, Baxter Healthcare Corp., Round Lake, IL.

[b]Vi-Drape Wound Protector, Becton Dickinson AcuteCare Division, Franklin Lakes, NJ.

[c]Dexon, Davis & Geck, Inc., American Cyanamid Co., Manati, PR.

[d]PDS II, Ethicon, Inc., Somerville, NJ.

Figure 55–1.


A Incision
B Grasping bladder with stone
Side view
C Blunt separation of calculus from mucosa
D Closure of bladder wall
Lembert pattern in serosa
Simple continuous or Cushing pattern in mucosa
F.Paraz

Postoperative Management

Fluid diuresis to aid removal of remaining blood clots, calculus crumbs, and debris from the bladder is important and can be effected by the rapid intravenous administration of 4 L of 5% glucose. The maintenance of an indwelling urinary catheter as a safeguard to the cystotomy closure has been recommended, but we do not routinely use it.[5] Phenylbutazone, 2 g/day for 2 to 3 days, provides suitable nonsteroidal anti-inflammatory therapy. Antibiotic therapy beyond the day of surgery should be reserved for cases with known bacterial cystitis and should be based on preoperative urine culture and sensitivity testing. Ammonium chloride has been attempted as a urine acidifier to prevent recurrence of urolithiasis, but its efficacy has not been studied.[1] Ascorbic acid has been shown to be the safest and most effective agent to acidify the urine of horses rapidly, but it has not been evaluated as a method of preventing urolithiasis.[6]

Horses that have undergone laparocystidotomy should be confined to a stall, with hand walking only, for 4 to 6 weeks before resuming exercise. Bladder leakage or dehiscence, peritonitis, wound infection, and recurrence of calculus formation are potential complications. Careful surgical technique and attention to detail help to prevent bladder and wound problems. Recurrence of urolithiasis is believed to be higher after perineal urethrotomy than after laparocystidotomy but can be the result of undetected calculi at other sites in the urinary system as well.[1, 3] In uneventful cases, the hematuria and dribbling of urine cease almost immediately after surgery.

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Fracture Repair

chapter 56

Principles of Lag Screw Fixation

Interfragmentary compression pulls bone fragments together, increasing the frictional resistance to motion between the fragments and restoring the functional continuity of the bone. Compression per se has no osteogenic properties, but it improves stability.[1] Stable bone fragments may function as though the fracture fissure were not present. The simplest method of compressing two fragments is to lag them with a screw. Numerous equine fractures are repaired with interfragmentary compression using lag screws. These fractures include large extensor process fractures of the distal phalanx, midsagittal fractures of the distal phalanx, longitudinal fractures of the proximal phalanx, stress fractures of the metacarpus, condylar fractures of the metacarpus or metatarsus, slab fractures of the third carpal bone, and certain proximal sesamoid bone fractures.

To achieve compression of bone fragments with a lag screw, the threads of the screw must engage only the far (trans) cortex or the far fragment of the fractured bone. The threads should not engage the cortex or any part of the fragment closest to the head of the screw. As the screw is tightened, the head contacts the near (cis) cortex and moves toward the far fragment, pulling the two fragments together. Compression of two fragments of bone can be achieved with partially threaded or fully threaded screws. Partially threaded screws are inserted so that all the threads pass the fracture line and are in the far fragment (Fig. 56–1*A*).[2] Fully threaded screws are used more commonly and must be placed with a lag screw technique.[2] The near cortex is drilled with a hole large enough so that the screw threads do not engage the bone. This is called *overdrilling,* and the overdrilled part of the screw hole is termed the *gliding hole.* The hole in the far cortex is smaller so the threads will engage the bone when the screw is inserted. This hole is called the *thread hole.* In hard equine bone, overdrilling must extend to the fracture line to ensure compression when the screw is tightened (Fig. 56–1*B*).

Figure 56–1.

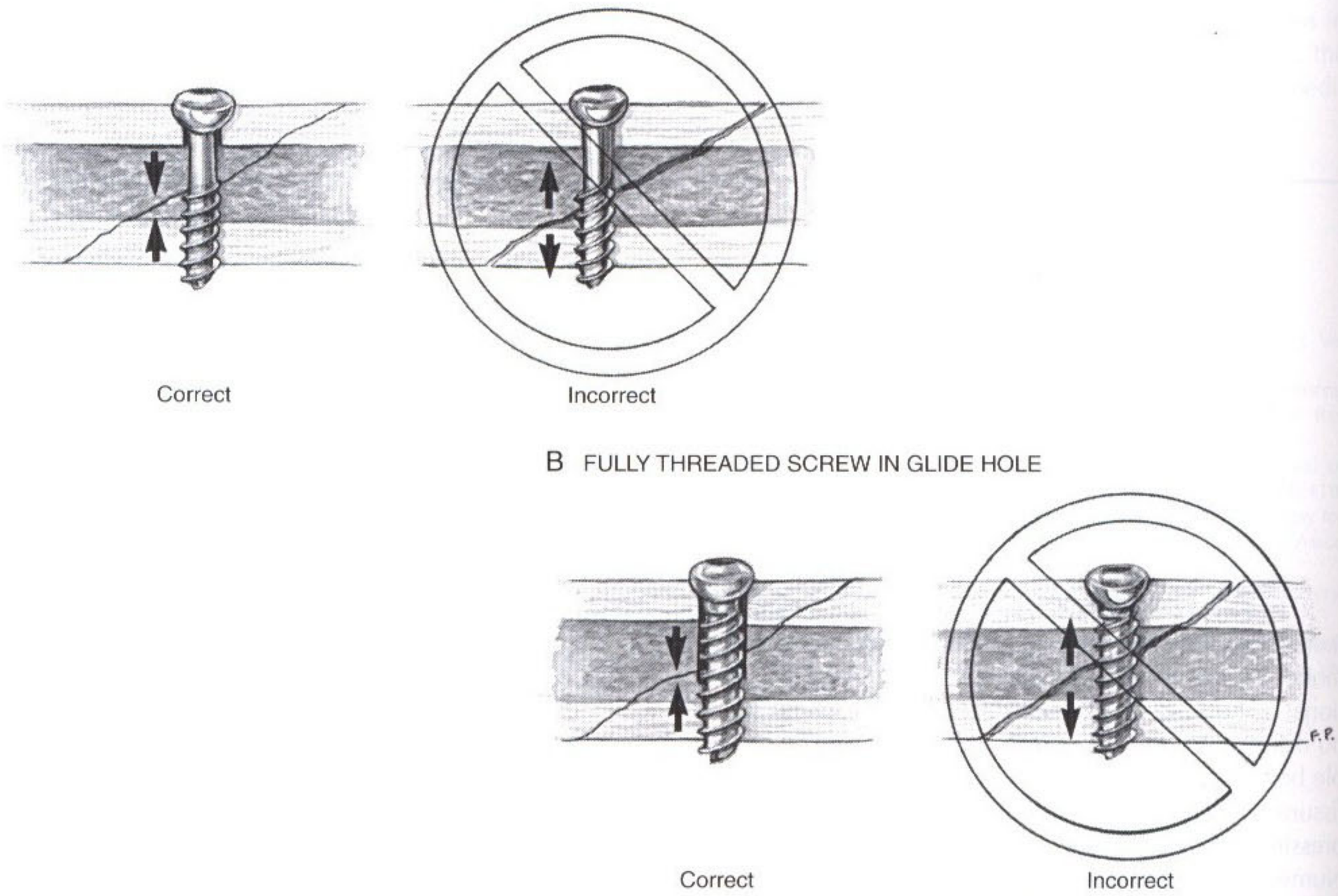


Illustration continued on page 277

Numerous different sizes and types of screws can be used for interfragmentary compression. The most widely used screws are designed by the Association for Osteosynthesis/Association for the Study of Internal Fixation (AO/ASIF) and distributed in the United States by Synthes.[a] Satisfactory screws are available from other companies. The sizes and characteristics of screws available for equine surgery from AO/ASIF are summarized in Table 56–1. All of these screws can be inserted into bone as lag screws. The 5.5-mm cortical screw has been shown to have greater strength in equine bone than the 4.5-mm cortical or the 6.5-mm cancellous screws and is preferred by many equine surgeons.[2] However, 5.5-mm screws are too large for some applications, and smaller sizes should be available.

A key step in the insertion of lag screws is correct drilling of holes in the bone to achieve compression. Proper drilling of holes will improve stability of the fixation.[3] Drill holes should be round, which requires stability of the drill during drilling. Power drills allow more control and are less likely to wobble than hand drills. Drill guides will aid stability and reduce wobble. Bending of the drill bit will cause the holes to be out of round. Production of heat should be minimized to reduce damage to bone surrounding the drill hole. Heat can be reduced by using sharp drill bits, which cut

[a]ASIF instruments and implants, Synthes (USA), Paoli, PA.

Table 56–1.

Bone Screws for Equine Surgery

Variable	3.5-mm Cortex	4.5-mm Cortex	4.5-mm Cannulated		5.5-mm Cortex	6.5-mm Cancellous	7.0-mm Cannulated
Screw diameter	3.5	4.5	4.5		5.5	6.5	7.0
Gliding hole diameter	3.5	4.5	None	4.5	5.5	(4.5)	None
Thread hole diameter	2.5	3.2	3.2		4.0	3.2	4.5
Screw tap diameter	3.5	4.5	4.5		5.5	6.5	7.0
Screw shape							
Thread type	Cortical	Cortical	Cancellous		Cortical	Cancellous	Cancellous
Screw head diameter	6.0	8.0	6.5		8.0	8.0	8.0
Thread length	Entire length	Entire length	16.0	Entire length	Entire length	16.0 / 32.0 / Entire length	16.0 / 32.0
Shaft diameter	—	—	3.1	—	—	4.5 / 4.5 / —	4.5
Core diameter	2.4	3.1	2.7		4.0	3.0	4.5
Self-tapping	Yes	Yes	Yes		—	—	—

Adapted from Auer JA: Surgical equipment and implants for fracture repair. In Nixon AJ (ed): Equine Fracture Repair. Philadelphia: WB Saunders Co., 1996, p 56.

quickly; clearing the flutes of the bit periodically to reduce the trapping of bone debris, which reduces or halts the cutting action; and irrigating while drilling, which lubricates the bit and facilitates removal of debris, thus reducing friction and heat production.[3] Cutting bone threads with a tap is recommended in the dense cortical bone of horses. Self-tapping screws are available; however, they are difficult to insert in the extremely hard cortical bone of mature horses.

Lag screws compress fragments as the screws are tightened. The axial force achieved by a screw is directly proportional to the torque applied to the screw.[4] The proper amount of torque required to tighten screws without stripping threads or breaking the screw may be difficult to judge and requires surgical experience. Screws should be tightened with much less force in the soft cancellous bone of foals than in the hard cortical bone of adult horses. Generally, we tighten screws in soft bone by grasping the screwdriver with only fingers. In hard bone we grasp the screwdriver in the palm of the hand and tighten moderately firmly.[3] Studies in mature equine metacarpal and metatarsal bones using 4.5-mm cortical screws revealed that failure occurs because screws break, not because bone threads strip.[4] Our experience suggests that most 5.5-mm cortical screws fail the same way in mature equine cortical bone. Bone thread failure is most common in the cancellous bone of foals.

Insertion of Fully Threaded Screws

Insertion of fully threaded screws as lag screws requires specific instruments to obtain effective compression. A drill and two sizes of drill bits are required. The larger drill bit is the same diameter as the threads of the screw. The smaller drill bit is usually the size of the core of the screw. A double drill guide or drill guide with a smaller insert is required so that the drill bit can be stabilized with an appropriately sized guide. A countersink, depth gauge, and tap to cut threads are also required. A screwdriver with a hexagonal head is used to insert the screws.

The fracture fragments should be reduced and held in reduction with bone clamps, wires, or small pins. The near cortex is perforated with a drill bit the same diameter as the threads on the screw. The larger of two drill sleeves sized for the screw should be used. The drill bit should penetrate to the fracture fissure or slightly beyond, ensuring that the gliding hole is long enough to prevent the screw threads from engaging the near cortex or fragment (Fig. 56–1*C*). The smaller drill sleeve or the insert drill sleeve is placed into the gliding hole to guide the drill bit for the thread hole in a direct line and concentric with the gliding hole. The thread hole is drilled through the far (trans) cortex (Fig. 56–1*D*). The drill bit and drill sleeve are removed.

The near cortex of most holes is contoured to the head of the screw with a countersink (Fig. 56–1*E*). The countersink is turned in only one direction to create a smooth, congruent surface that matches the screw head. This increases the contact area between the screw and bone and improves the distribution of force under the screw head. The depth of the countersink must be adjusted to the thickness of the cortex. Bone with a thin cortex should be countersunk minimally or not at all to avoid the risk of a screw head's pulling through the cortex as the screw is tightened. A depth gauge is used to determine the proper length for the screw. The tip of the depth gauge is inserted into the hole just beyond the far cortex, and the gauge is tilted slightly as the hooked tip is retracted until it catches on the outer surface of the far cortex. The shoulder of the gauge should be seated in the countersink hole, and the screw length is determined by reading the number on the gauge (Fig. 56–1*F*).

The tap is used to cut threads in the thread hole (Fig. 56–1*G*). To protect the soft tissues, it is inserted through a tap sleeve or the large drill sleeve into the gliding hole. Bone threads are cut by turning the tap three half-turns forward and one half-turn backward. This action clears the threads of bone debris, which collects in the flutes of the tap, and improves the cutting action of tap, creating cleanly cut bone threads. The tap should be lubricated with sterile fluids while cutting threads. The tap should never be turned forward with excessive force, which can strip the bone threads or break the tap. Screw holes drilled incompletely though the trans cortex will cause the tap to bottom out and not advance. If the tap becomes difficult to advance, it should be removed from the hole, cleaned of debris, and inspected for damage. The length of the screw hole may also be rechecked. Unfortunately, rechecking the length of the hole can damage the bone threads. After threads are cut the tap is withdrawn, the screw hole is flushed liberally with sterile fluids, and a screw of proper length is inserted.

In equine fracture repair, the length of the screw to be inserted is the same as the measured length of the hole or 2 mm shorter. A shorter screw is used in bone with a very thick cortex or when fracture reduction is imperfect, and a fracture gap will be closed by compression as the lag screw is tightened. This effectively shortens the length of the measured hole. The screw is seated on the screwdriver and inserted. It should slide through the gliding hole and engage the thread hole (Fig. 56–1*H*). The screw should be tightened securely without breaking it or stripping the bone threads. The method for insertion of fully threaded screws with the lag screw technique is identical for all sizes of screws. The size of the drill bits and instruments varies according to the size of the screws.[2]

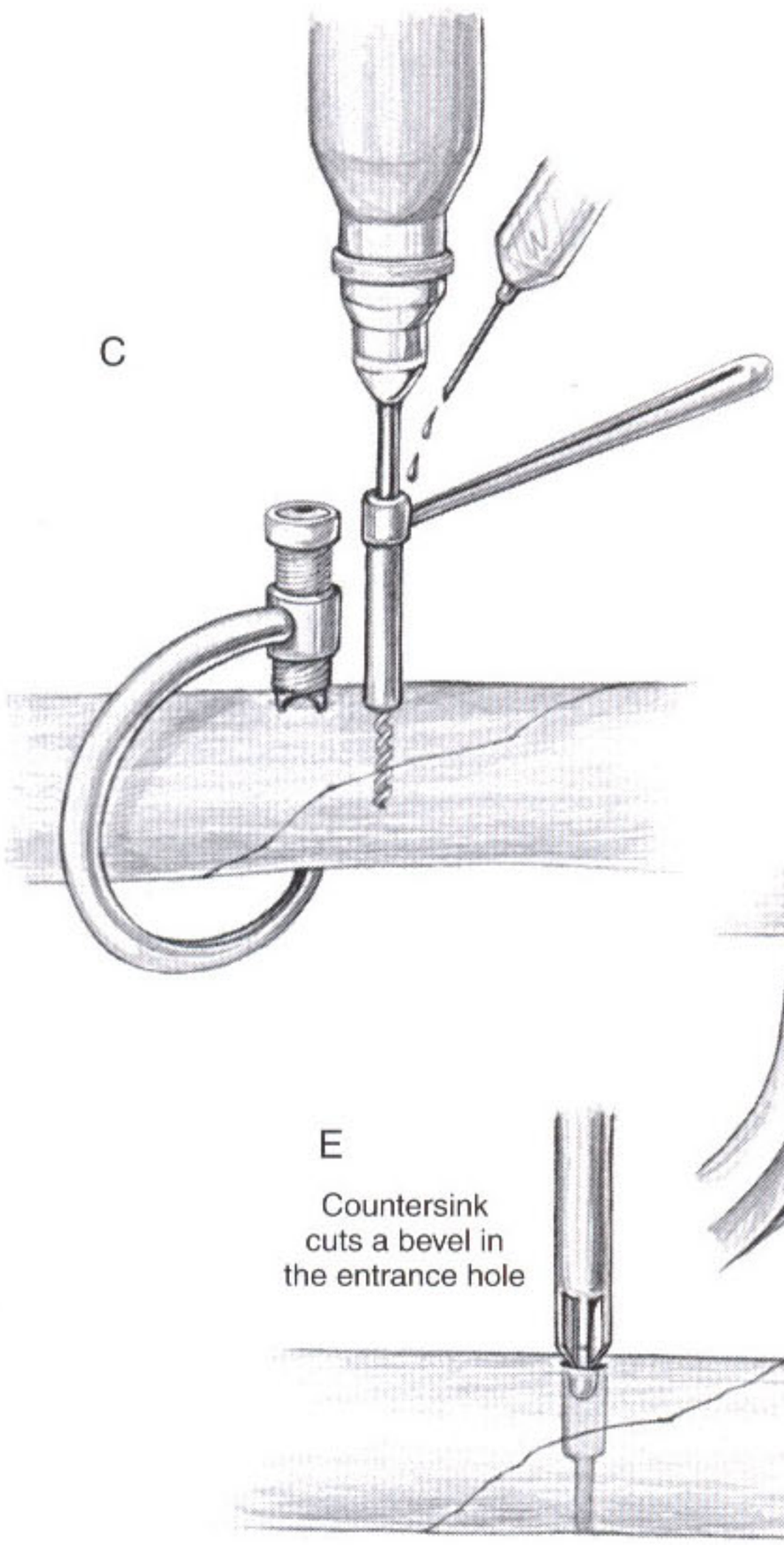
Insertion of Partially Threaded Lag Screws

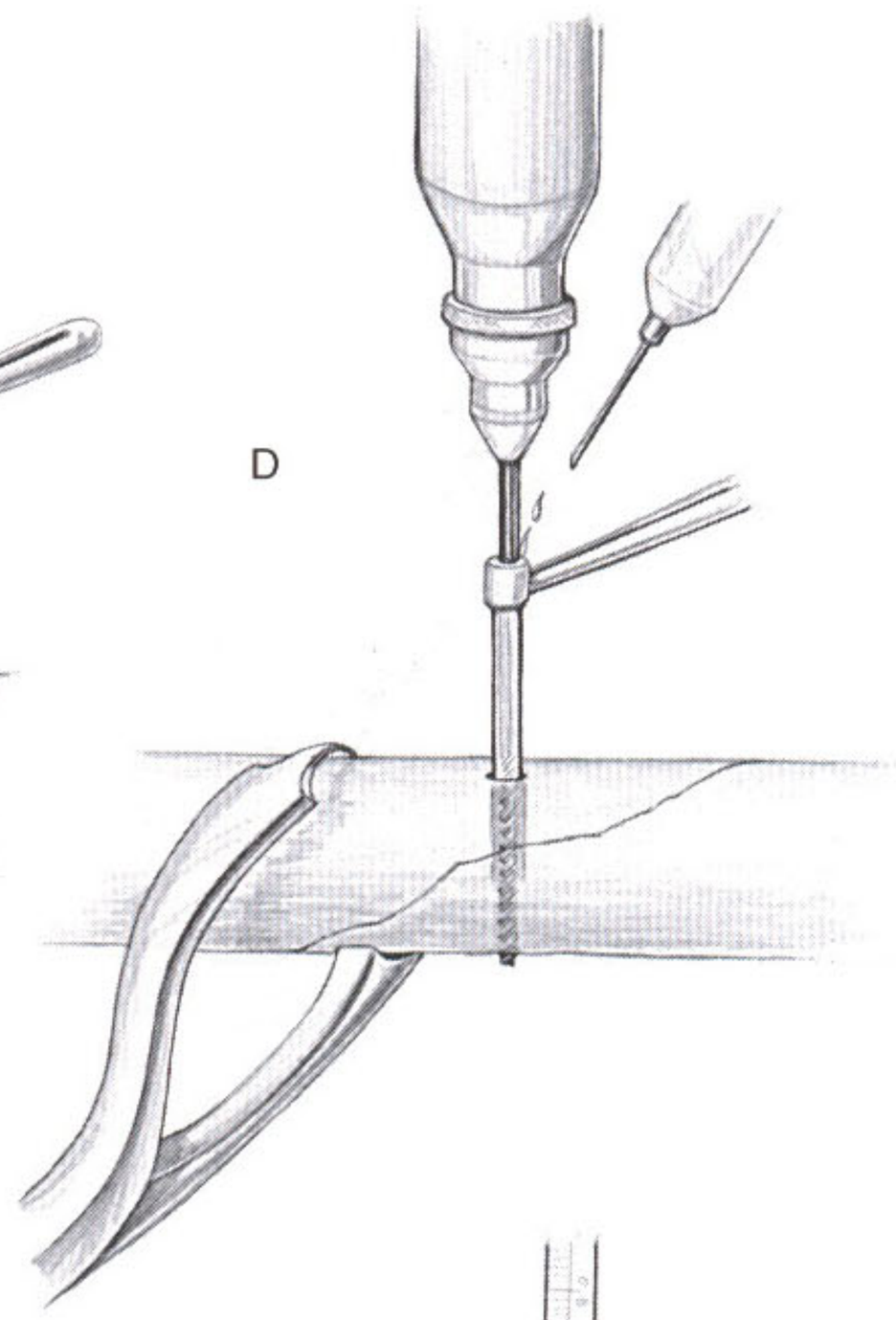
Interfragmentary compression can be achieved with partially threaded cancellous screws without drilling two different-sized holes. To insert the cancellous screws in lag fashion, one thread hole is drilled in both cortices and across the fracture line. Threads are cut with a cancellous bone tap of the appropriate size along the entire length of the drill hole. As the screw is inserted, the threads of the screw engage the far cortex and fragment, and the narrower shaft of the screw glides through the near cortex. As the screw is tightened, compression occurs. It is essential that the threads do not cross the fracture line. In the AO/ASIF system, partially threaded 4.5-mm and 7.0-mm cannulated cancellous screws and partially threaded 6.5-mm cancellous screws are currently available (see Table 56–1).

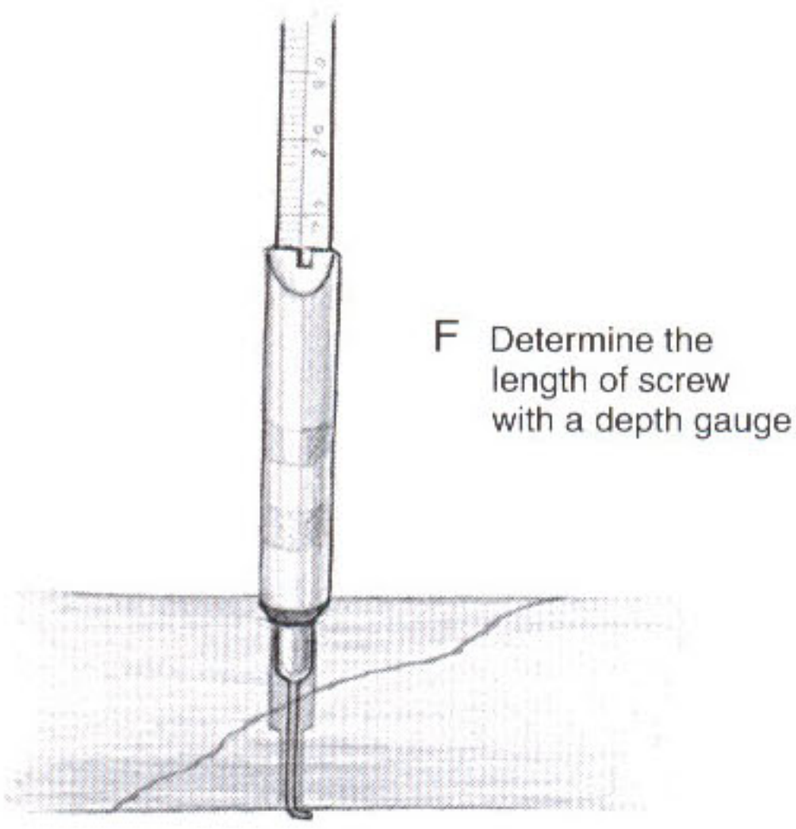
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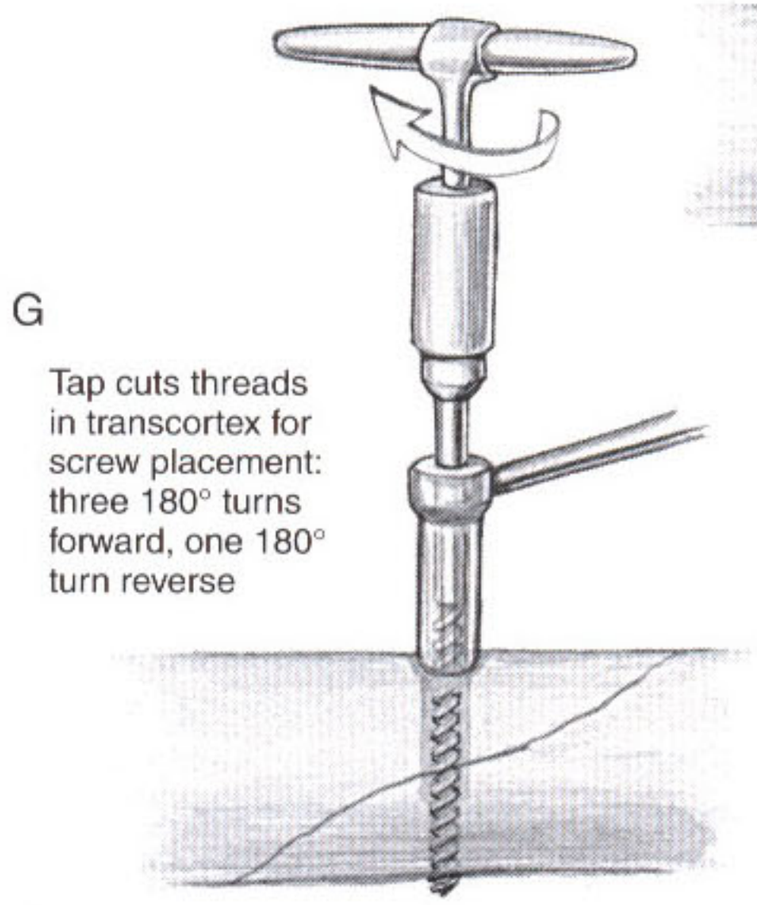
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Figure 56–1. *Continued*









chapter 57

Lag Screw Fixation of Third Carpal Slab Fractures

Slab fractures of the third carpal bone extend between two articulations: the middle carpal joint and the carpometacarpal joint. Slab fractures have numerous configurations and occur in frontal and sagittal planes. The most common slab fracture occurs in the frontal plane of the radial facet on the dorsomedial aspect of the third carpal bone.[1, 2] Slab fractures occur most often in racehorses in the right forelimb.[3] Fractures may be nondisplaced or displaced; the latter occur in approximately 50% of Standardbreds and 75% of Thoroughbreds sustaining slab fractures.[2] Not uncommonly, horses have received intra-articular steroids in the affected joint before fracture.[4]

Slab fractures usually occur during high-speed exercise. Horses exhibit mild (grade 1) to severe (grade 5) lameness, depending on the configuration and displacement of the fracture. Effusion in the middle carpal joint is consistently present. Good-quality radiographs are needed to evaluate the fracture accurately. Projections should include a dorsopalmar, lateromedial, flexed lateromedial, dorsolateral-palmaromedial oblique, dorsomedial-palmarolateral oblique, and dorsoproximal-dorsodistal oblique view of the distal row of carpal bones. The last view is essential to determine the size, width, and location of the slab fracture and to determine whether the fracture is comminuted. The dorsoproximal-dorsodistal oblique view is also likely to reveal sagittal fractures, which may be difficult to detect on the other views.

Slab fractures of the third carpal bone in the frontal plane have been treated by stall rest, surgical excision of the fracture fragment, and lag screw fixation. Treatment selection depends on the value of the horse, the sex and breed of the horse, the intended future use, the size of the slab fragment, the amount of displacement, the presence of comminution, and the prospects for fracture reduction.[4] Stall rest is satisfactory for all horses with nondisplaced fractures not intended for future racing. The treatment of Standardbreds with nondisplaced third carpal bone fractures by rest results in performance and convalescent times that are similar to those associated with resection of the fragment or lag screw fixation.[2] In one study, 10 of 12 Standardbreds treated with rest subsequently raced.[2] However, rest is not as effective for the treatment of slab fractures in Thoroughbreds, and surgery is recommended.[3] Horses with third carpal slab fractures treated by fragment removal may race successfully. However, the thickness of the fragment should be less than 8 mm in Thoroughbreds and 14 mm in Standardbreds.[2] Small comminuted slab fractures, fragments that are displaced or do not reduce well because of fibrosis, and thin slab fractures that may split from lag screw fixation are suitable for excision. Lag screw fixation of third carpal slab fractures should be considered for horses with displaced frontal plane slab fractures, for horses with wide fractures that involve the radial and intermediate facets of the third carpal bone, and for all Thoroughbred racehorses. Lag screw fixation will often decrease convalescent time and reduce the development of osteoarthritis.

Lag screw fixation of dorsomedial slab fractures can be performed with arthroscopic guidance or via a standard arthrotomy incision.[3–7] Arthroscopically guided lag screw fixation is the preferred method of repair.[3, 6] Using arthroscopic visualization, damaged cartilage and bone fragments within the middle carpal joint are removed, and a lag screw is inserted to compress the fracture. This method of fixation can be performed only if the slab fracture is nondisplaced or if the displaced slab fragment is reduced when the carpus is flexed. Arthroscopic repair is technically difficult and requires extensive experience, and not all surgeons will have the skills or the equipment required.[5] The reader is referred to other sources for a description of lag screw fixation with arthroscopic guidance.[3–6] Lag screw fixation using a dorsomedial arthrotomy incision is a standard approach.[2] The same surgical incision can be used to remove slab fragments and to remove small osteochondral fractures from the radial carpal or third carpal bone. Arthrotomy should be used for lag screw fixation when fracture reduction does not occur when the carpus is flexed.

Anesthesia, Positioning, and Surgical Preparation

Equipment necessary for surgery, in addition to standard surgical instruments, includes bone curets, a periosteal elevator, a self-retaining retractor, a tourniquet, an assortment of 4.5-mm cortical bone screws from 24 to 36 mm long, and the instruments required for inserting the screws with a lag technique.[a] Equipment to take intraoperative radiographs should be available. Before induction of anesthesia, hair is clipped from the fetlock joint to the middle of the radius around the entire circumference of the limb. Broad-spectrum perioperative antibiotics are administered intravenously, as is phenylbutazone at 4.4 mg/kg body weight. After induction of anesthesia, the horse is positioned in lateral recumbency with the affected limb down or in dorsal recumbency. When the horse is positioned in lateral recumbency, a tourniquet is placed on the limb just distal to the elbow joint to reduce hemorrhage. The dorsal carpus is shaved and the skin surgically prepared. We recommend using an impervious self-adhering plastic barrier drape[b] so that the carpus and third metacarpal bone can be visualized during surgery to assist in proper positioning of the screw (see Chapter 3).

Surgery

The carpus is flexed approximately 30°, and the extensor carpi radialis tendon and the middle carpal joint space are identified. A straight 5- to 6-cm-long skin incision, parallel and just medial to the extensor carpi radialis tendon, is made from the middle of the radial carpal bone to the dorsal aspect of the third carpal bone (Fig. 57–1*A*). This incision is carried deeper through the subcutaneous tissue, the extensor carpi retinaculum, the joint capsule, and synovial membrane of the middle carpal joint. Self-retaining Gelpi[c] or Weitlaner[d] retractors are placed in the wound and opened to expose the articular surface of the dorsomedial aspect of the third carpal bone and the distal articular surface of the radial carpal bone. The articular surfaces are examined, and the size, exact location, and width of the slab fracture are determined. Most fractures have a wedge of bone and cartilage at the fracture site, which should be removed (Fig. 57–1*B*). With displaced fractures, the fracture gap must be cleaned of hemorrhage, fibrin, and bone debris.

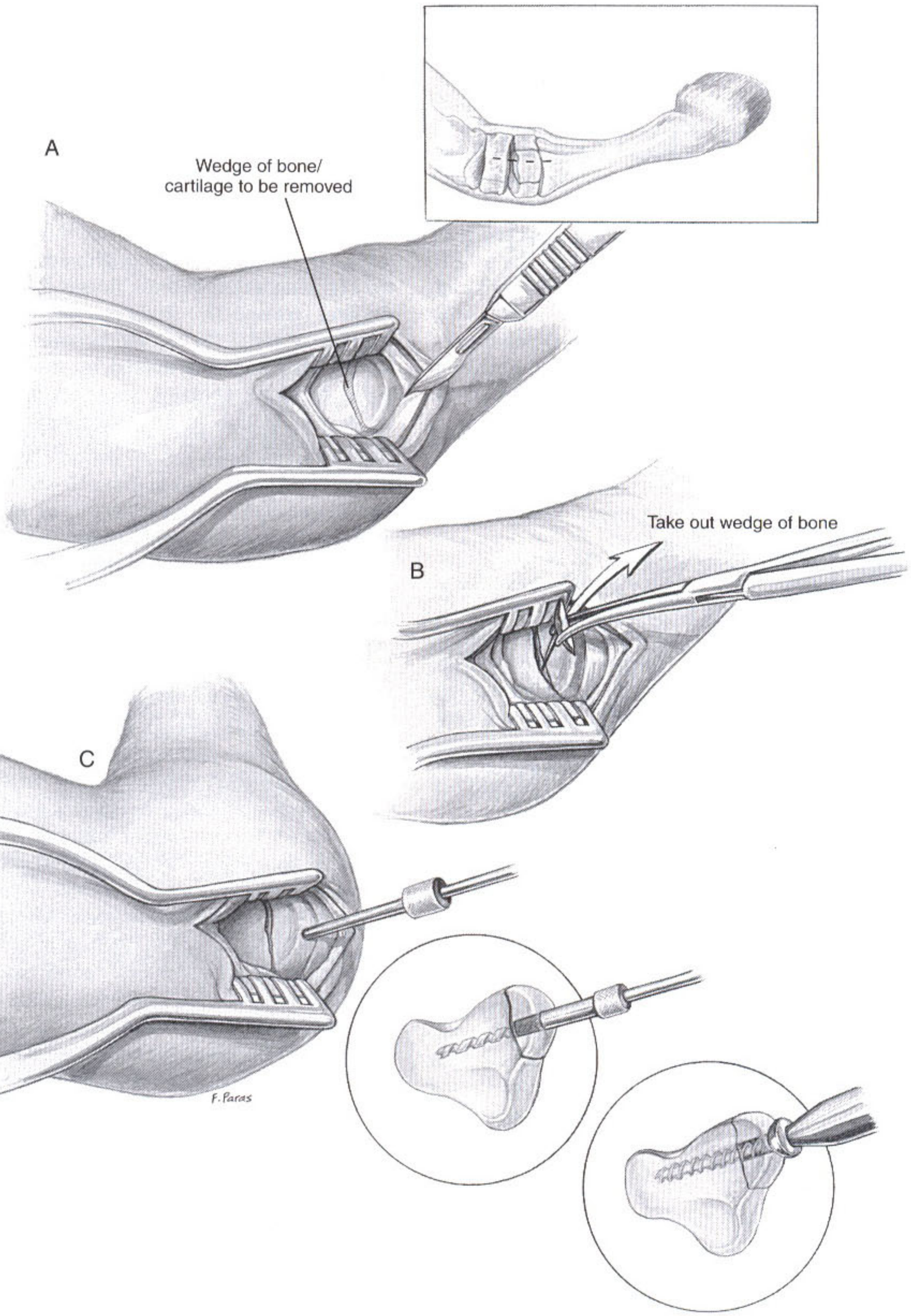
The carpus is fully flexed to reduce the slab fracture during insertion of the lag screw (Fig. 57–1*C*). The lag screw should be inserted in the middle of the slab fragment, halfway between the two articular surfaces and halfway between the medial and lateral extent of the fracture. When the center of the slab fracture is aligned with the arthrotomy incision, the periosteal elevator is used to lift the joint capsule off the face of the third carpal bone at the point of screw insertion. When the center of the slab fracture is directly under the tendon of the extensor carpi radialis tendon, a 1-cm-long stab incision directly through the tendon and parallel to tendon fibers is made down to the face of the bone to insert the screw. Usually the stab incision through the tendon can be made through the original skin incision.

As described in Chapter 56, 4.5-mm cortical lag screws are inserted according to standard lag screw technique. Using a drill guide to prevent entrapment of soft tissues, the 4.5-mm gliding hole is drilled through the center of the slab fracture parallel to the joint surface, perpendicular to the fracture line and perpendicular to the dorsal aspect of the third metacarpal bone (see Fig. 57–1*C*). The gliding hole should be at least 12 mm deep, even when the slab fragment is thinner, to permit adequate countersinking. The ASIF countersink requires a 12-mm-deep hole in order to cut the surface of the bone. A ruler can be used to determine the depth of the 4.5-mm gliding hole as it is being drilled. The 3.2-mm drill sleeve is inserted into the 4.5-mm hole, and the 3.2-mm thread hole is drilled. This hole should not penetrate the palmar aspect of the third carpal bone to avoid damage to the structures in the carpal canal or to the fourth carpal bone. A thread hole 20 mm long is adequate to provide satisfactory purchase of the 4.5-mm cortical screw. A ruler should be used to measure the hole as it is being drilled. The hole is countersunk, measured for screw length, and tapped. The tap should not be advanced after it has reached the bottom of the hole, or the bone threads will strip or be weakened. A screw 2 to 4 mm shorter than the measured depth of the hole is selected to ensure that the screw will not reach the bottom of the hole before the fracture compresses. The screw is inserted and tightened while visualizing the articular surface of the third carpal bone, ensuring adequate reduction, alignment, and compression. When large articular defects along the fracture gap have been removed, the proximal aspect of the slab fragment may protrude proximally and impinge on the radial carpal bone during full extension of the joint. When necessary, this protuberance of cartilage and bone can be removed with rongeurs to improve stability of the lag screw repair.

Smaller cortical screws, such as the ASIF 3.5-mm cortical screw, can be used when the slab fracture is thin and when two screws are necessary to stabilize wide fractures that involve both the radial and intermediate facets. The smaller screws require less countersinking of the bone for proper contact of the screw

[a]ASIF instruments and implants, Synthes (USA), Paoli, PA.
[b]Ioban2, Animal Care Products, 3M Health Care, St. Paul, MN.
[c]Gelpi retractor, Miltex Instrument Company, Inc., Bethpage, NY.
[d]Weitlaner retractor, Miltex Instrument Company, Inc., Bethpage, NY.

Figure 57–1.


A
Wedge of bone/
cartilage to be removed
B
Take out wedge of bone
C
F. Paras

head and are less likely to cause a thin slab fragment to split as the screw is tightened. Slab fragments that split intraoperatively are usually thin, and removal of the fragment is recommended.

After lag screw fixation, the joint is lavaged vigorously to remove any debris. The self-retaining retractor is removed, and the carpus is moved to the original position of about 30° of flexion. The joint capsule of the middle carpal joint is closed with simple interrupted sutures of size 2–0 polydioxanone.[e] Two or three interrupted sutures using the same material can be placed in the extensor carpi radialis tendon if a separate stab incision has been made for screw insertion. The extensor carpi reticulum is closed using the same pattern and material. The subcutaneous tissue is closed with a simple continuous pattern using size 2–0 or 3–0 polydioxanone, and the skin is closed routinely. A sterile wound pad is secured with sterile gauze, and a heavy full limb bandage is placed on the limb before recovery.

Postoperative Management

Broad-spectrum antibiotics are continued postoperatively for 3 days when corticosteroids have been instilled in the joint before surgery. Nonsteroidal anti-inflammatory drugs are given for 24 hours, or longer if lameness persists. The most common complication of dorsomedial slab fractures of the third carpal bone is the development of osteoarthritis. Horses with significant cartilage damage and severe synovitis in the middle carpal joint may benefit from the administration of hyaluronic acid and polysulfated glycosaminoglycans in the postoperative period. The bandage should be maintained for 3 weeks and changed every 2 to 3 days. The horse should be rested in a stall for 8 to 10 weeks. During this period, the horse can be hand walked for 5 to 15 minutes daily, and the limb should be picked up and the carpus flexed up to 10 times daily as far as the horse will comfortably allow to re-establish full range of motion. The horse can be turned out in a small paddock for an additional 10 to 12 weeks, provided that radiographs show the fracture to be healing normally. Alternatively, the horse can swim in a pool for this period.[6] Training generally resumes in 6 months. The mean time from surgery to the first race is approximately 10 months in Thoroughbreds and 11.5 months in Standardbreds.[2, 4]

After lag screw fixation of third carpal slab fractures, nearly 67% of Thoroughbreds raced.[4] However, the claiming value of these horses decreased by 50%.[4] Another retrospective study revealed that 65% of Thoroughbreds and 77% of Standardbreds raced after sustaining slab fractures treated by rest, excision, or lag screw fixation.[2] Females were less likely to race, and lag screw fixation in Thoroughbreds with a fragment depth greater than 9 mm was associated with poor performance.[2]

[e]PDS II, Ethicon, Inc., Somerville, NJ.

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chapter 58

Repair of Condylar Fractures of the Third Metacarpus and Third Metatarsus

Longitudinal fractures of the third metacarpal and third metatarsal condyles occur most frequently in racehorses.[1] The lateral condyle of the metacarpus is most often fractured in the Thoroughbred, whereas fractures of metacarpal and metatarsal condyles occur equally in the Standardbred.[2] Condylar fractures may be incomplete, complete and nondisplaced, or complete and displaced. Complete displaced fractures of the lateral condyle are most common.[1] Medial condylar fractures of the metatarsus are usually nondisplaced and incomplete.[3] However, these fractures often spiral up the metatarsal bone into the diaphysis, and catastrophic failure of the metatarsus may occur. Medial metatarsal fractures should be carefully evaluated with excellent-quality radiographs, stabilized with lag screw fixation, and protected from catastrophic failure with external coaptation before and after surgery.[4]

Condylar fractures are often complicated by additional injuries to the fetlock or with preexisting disease. Comminution of the fracture at the palmar articular aspect of the condyle may occur.[1] Fractures of the proximal sesamoid bone[5] and osteochondral fractures of the proximal dorsal aspect of the proximal phalanx have been noted to accompany condylar fractures.[5] Injury to the collateral ligaments, joint capsule, cartilage, and suspensory ligament may also occur concurrent with the condylar fracture. Diseases present before condylar fracture, such as suspensory desmitis, osteoarthritis, and subchondral lucency of the palmar surface of the condyle, may alter the outcome of treatment. A thorough history and physical examination and excellent-quality radiographs are needed to detect and evaluate concurrent lesions and to give an accurate prognosis. Radiographic views of the fetlock should include a dorsodistal-palmaroproximal oblique (125° dorsopalmar metacarpal skyline) view or a flexed dorsopalmar/plantar view of the palmar/plantar condyles to detect comminution of the fracture and condylar erosions.[1]

Condylar fractures have been treated by support bandaging and stall rest, cast immobilization, and lag screw fixation.[2] Lag screw fixation is indicated in all horses with complete displaced fractures and in athletic horses with complete nondisplaced fractures. Some surgeons prefer to repair incomplete fractures with lag screws, but these fractures frequently heal satisfactorily with rest.[1] Complete fractures may heal with rest or cast immobilization, but the fetlock joint often develops osteoarthritis. The advantages of lag screw fixation of condylar fractures include improved alignment of displaced fragments, improved healing of the articular surface, prevention of fracture propagation, prevention of displacement of nondisplaced fractures, and shortening of the convalescent period.[5]

Anesthesia, Positioning, and Surgical Preparation

Broad-spectrum perioperative antibiotics are administered intravenously, and general anesthesia is induced. The horse is positioned in lateral recumbency with the limb positioned so that the fractured condyle is uppermost. Surgical preparation of the limb should extend from the coronary band to the carpus or tarsus. An Esmarch or pneumatic tourniquet may be used during surgery and is especially helpful if the injured limb is lowermost (see Chapter 4).

Equipment for taking intraoperative images (radiography or fluoroscopy) should be available in the operating room. Lag screw fixation of the condyle can be performed with 4.5-mm-diameter or 5.5-mm-diameter cortical screws. The 4.5-mm screw is used most frequently and is strong enough for most repairs. The 5.5-mm screw is recommended for older fractures and fractures that are difficult to reduce.[4] An assortment of screws from 40 to 60 mm long and the equipment for

insertion of the screws with a lag screw technique should be available. An ASIF C-clamp drill guide,[a] ASIF bone reduction forceps, or Bishop clamp[b] is used to hold the condyle in reduction while screw holes are being drilled.

Condylar fractures of the third metacarpal and third metatarsal bones may also be repaired with Herbert compression screws.[c, 6] The Herbert screw has threads of different pitch at each end. The screw pulls the fractured fragments together as it is inserted into the bone. Advantages to this screw are that the entire screw is buried in bone and does not impinge on soft tissues, the screw is made of titanium alloy, and removal is not necessary.[6]

Surgery

Displaced Lateral Condylar Fractures of the Metacarpus

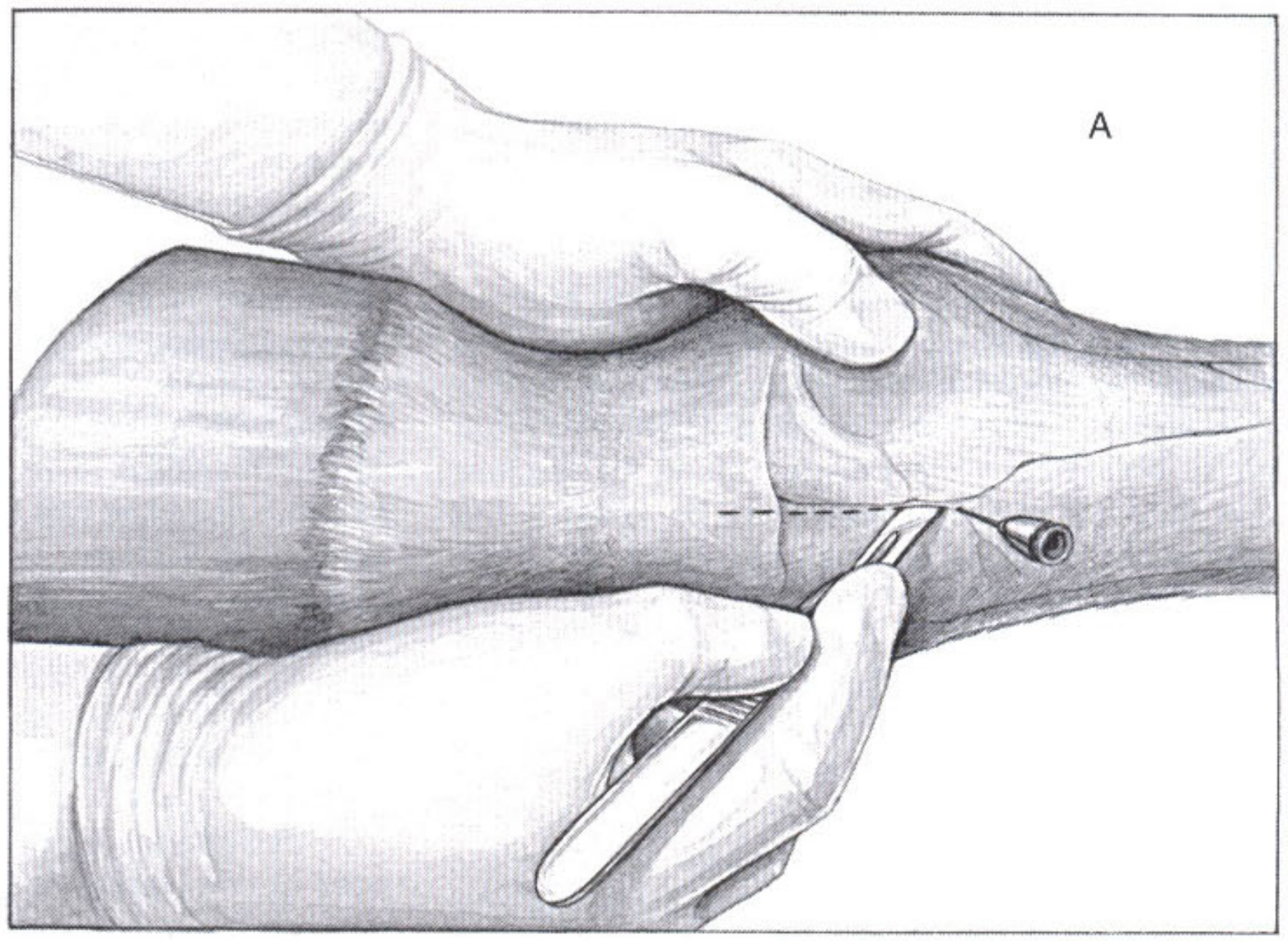
Two incisions are used to repair these fractures. The first incision is made on the dorsal metacarpus directly over the fracture and extends from the fetlock joint proximally for a distance of 5 to 7 cm. The fracture can be identified with needles before the incision is made. The incision extends through the skin, subcutaneous tissue, extensor tendon, and joint capsule directly into the fracture fissure (Fig. 58–1*A*). Gelpi[d] or Weitlaner[e] retractors are used to retract the soft tissues and expose the fracture (Fig. 58–1*B*). Blood, fibrin, and bone debris are removed from the fracture fissure. Comminuted fragments on the palmar aspect of the condyle can be removed by distracting the condylar fragment laterally and reaching through the fracture fissure to the back of the joint.[7] The fragments can be retrieved with a curved hemostat, a curved bone curet, or an angled Ferris-Smith rongeur.[f] The latter instrument is most useful. A second incision through the skin and subcutaneous tissues is made on the lateral aspect of the metacarpus directly over the lateral condyle. This incision extends from the apex of the fracture, where it breaks out of the lateral metacarpus, to just distal to the tubercle of the metacarpus (see Fig. 58–1*B*). The collateral ligament is exposed but not incised. Fibrin, blood, and any small loose pieces of bone are removed from the proximal aspect of the fracture, and the fracture is reduced by placing one or two ASIF bone reduction forceps with points across the metacarpus and closing them to compress the condylar fracture. The ASIF C-clamp or a Bishop clamp may be used instead of the bone reduction clamp. The articular surface of the condyle is visualized through the dorsal arthrotomy incision to determine proper joint alignment and fracture reduction.

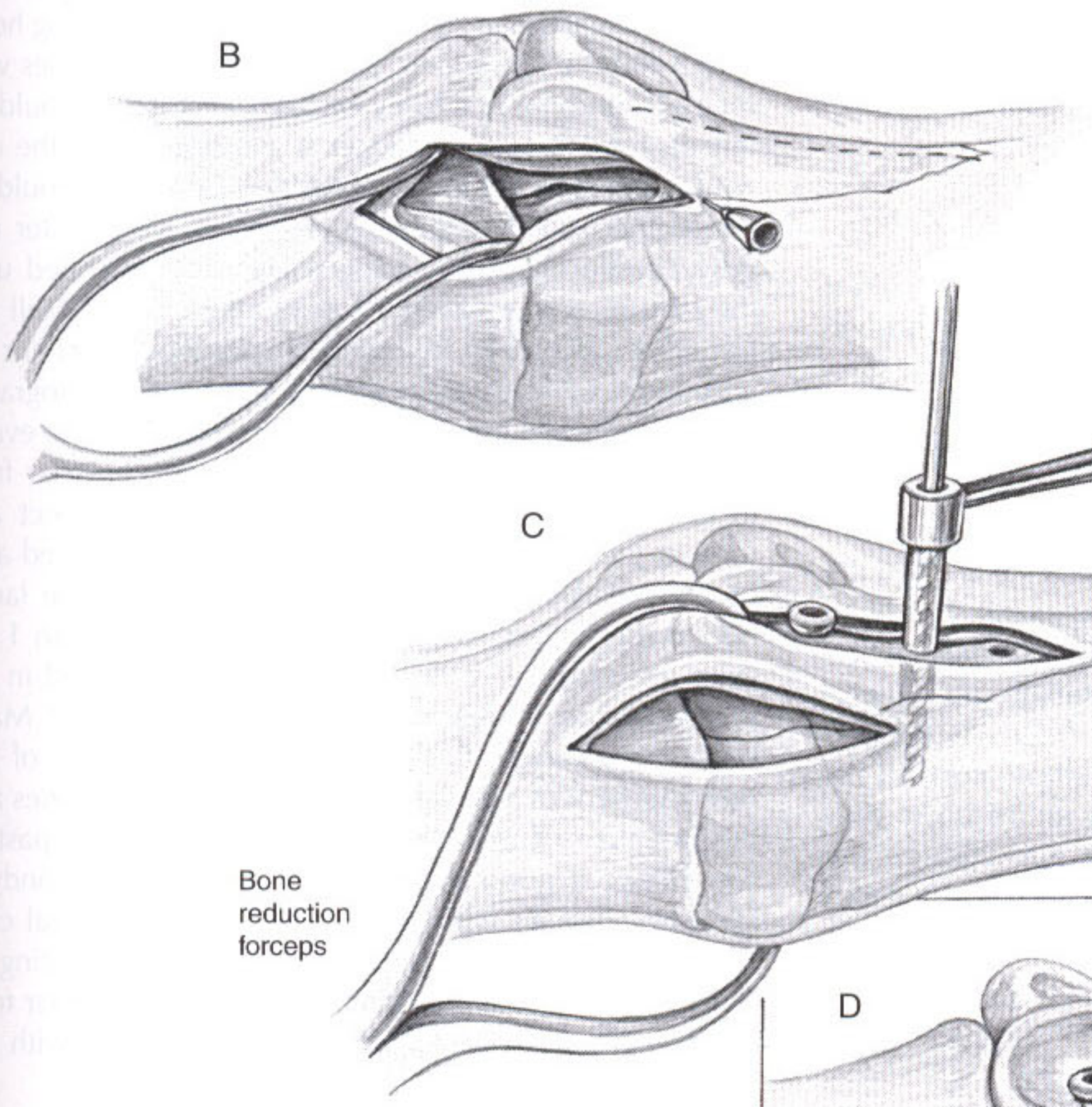
Before insertion of the first screw, a 2-mm drill bit or Kirschner wire[g] may be placed across the metacarpus parallel to the joint at the level of the tubercle. Dorsopalmar and lateromedial intraoperative images are taken to ensure proper reduction and to determine the location and direction of the first screw. The first lag screw should be placed parallel to the joint at the level of the condylar fossa (Fig. 58–1*C*). A small stab incision is made through the collateral ligament distal to the tubercle directly over the fossa. The scalpel blade can be felt to cut into the depression of the fossa.[4] For insertion of 4.5-mm diameter screws, the collateral ligament fibers are spread, a 4.5-mm drill sleeve is inserted to the depth of the fossa, and the 4.5-mm glide hole is drilled long enough to extend past the fissure. As the 4.5-mm drill sleeve is removed, hemostats should be used to maintain separation of the collateral ligament so the 3.2-mm drill guide can be inserted more easily into the glide hole. The thread hole is drilled to the opposite cortex but should not penetrate the cortex and damage the medial collateral ligament. The glide hole is not countersunk for the first screw to avoid additional damage to the collateral ligament. The depth of the hole is measured, and threads are cut with a 4.5-mm tap. A tap sleeve or the 4.5-mm drill sleeve should be used to protect the collateral ligament. The surgeon should be cautious not to strip the threads of the bone by forcing the tap to turn after it has reached the bottom of the thread hole. The screw hole should be flushed and all bone debris suctioned from the incision in the lateral collateral ligament to prevent postoperative mineralization. A screw 4 to 6 mm shorter than the measured length of the hole is inserted into the hole and partially tightened to compress the fracture slightly (see Fig. 58–1*C*). Reduction of the condyle can be monitored through the dorsal arthrotomy incision, and a dorsopalmar radiograph should be taken to evaluate the position of the screw. The screw should be parallel to the joint, cause reduction and alignment of the fracture, and not penetrate the medial cortex or the joint.

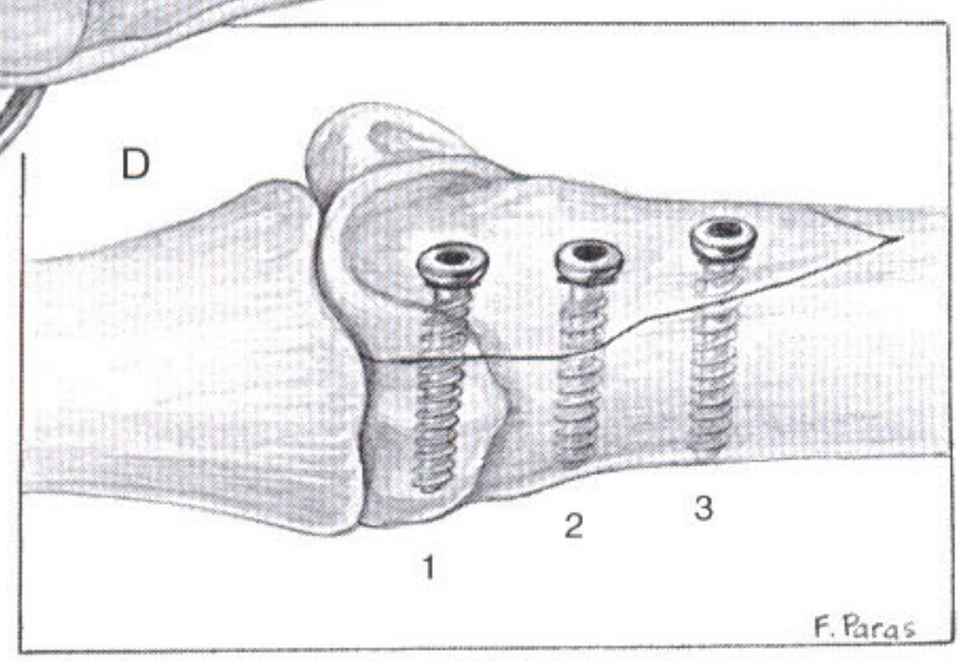
Depending on the length of the fracture, one to three additional screws are placed approximately 2 cm apart proximal to the first screw (Fig. 58–1*D*). Screws should not be placed closer than 1 cm to the apex of the fracture because they may break the thin fragment of condyle as they are tightened. Each screw is placed parallel to the first screw. The direction of the first screw can be ascertained easily by leaving the screwdriver

[a]ASIF instruments and implants, Synthes (USA), Paoli, PA.
[b]Bishop bone clamp, Miltex Instrument Company, Bethpage, NY.
[c]Herbert cannulated bone screw, Zimmer, Inc., Warsaw, IN.
[d]Gelpi retractors, Miltex Instrument Company, Bethpage, NY.
[e]Weitlaner retractors, Miltex Instrument Company, Bethpage, NY.
[f]Ferris-Smith rongeurs, Sontec Instruments, Englewood, CO.
[g]Kirschner wire, Synthes (USA), Paoli, PA.

Figure 58–1.







inserted into the head of previously placed screws. Each successive hole is then drilled parallel to the screwdriver. Each additional screw hole can penetrate the medial cortex because the holes are proximal to the collateral ligament. This maximizes the holding power of the screws because they can engage the dense cortical bone of the medial cortex. Also, the glide hole for each additional screw is countersunk to obtain a good fit of the screw head to the cortex. After all screws have been placed, they are sequentially tightened more snugly to obtain even compression along the fracture line. A final set of radiographs may be taken if the surgeon is unsure about position, alignment, or length of the screws.

The dorsal incision is closed with size 2–0 polydioxanone[h] suture material placed in the joint capsule and extensor tendon using a simple interrupted suture pattern. A simple continuous pattern of size 2–0 or 3–0 polydioxanone is placed in the subcutaneous tissues, and simple continuous sutures using size 2–0 polypropylene[i] are used to close the skin of both the dorsal and lateral incisions. Both surgical incisions are covered with a sterile nonadhesive pad, and the limb is placed in a half-limb cast or an aluminum orthopedic splint[j] to protect the limb during recovery from anesthesia.[4]

Nondisplaced Condylar Fractures

Lag screws can be inserted through stab incisions placed directly over the fractured condyle or through the same lateral incision described for displaced fractures. The dorsal arthrotomy incision is not needed because the fragments are aligned, and the fracture does not have to be cleaned of fibrin and hemorrhage. Intraoperative radiographic monitoring of screw position is necessary. The position of the lag screws and the technique for insertion are the same as those described for displaced lateral condylar fractures. Incomplete medial condylar fractures of the metatarsus and lateral condylar fractures that extend up the diaphysis are best treated by surgical stabilization.[4, 5] Multiple cortical lag screws or a bone plate spanning the entire bone may be needed to stabilize the fracture and reduce the chances of catastrophic failure. Determining the exact location of the fracture fissures is difficult but necessary for successful fixation. The fracture fissures of medial condylar fractures may not be clearly identified by radiographs. To identify the fissures, the entire dorsal diaphysis of the metatarsal bone can be exposed with a dorsomedial incision through skin, subcutaneous tissue, and periosteum adjacent to the extensor tendon. The periosteum is elevated to identify the fracture lines.[2] Screws placed through a fracture fissure do not contribute to stability and may contribute to bone failure. Horses with incomplete fractures of the lateral condyle can be managed in recovery with a firm bandage. A full-limb fiberglass cast incorporating the foot should be applied for recovery of horses with medial condylar fractures.[5]

Postoperative Management

Perioperative antibiotics are repeated within 1 hour of completion of surgery. Phenylbutazone at 2.2 mg/kg twice a day is given orally to control inflammation and pain and is continued as long as necessary. Half-limb casts can be removed from the standing horse 3 to 5 days after surgery. Full-limb casts on horses with medial condylar fractures of the metatarsus should be left on for 14 days or longer if the horse uses the cast well. After cast removal, a padded bandage should be maintained on the limb for at least 4 weeks after surgery. Sterile bandage changes are recommended until the sutures are removed 10 days after surgery. Stall rest for 60 to 90 days followed by paddock rest for an additional 60 to 90 days is recommended. Radiographs should be made before resumption of training to evaluate fracture healing. Surgically repaired condylar fractures generally heal first in the proximal aspect and then at the joint surface.[1] Screws are not removed after healing of the condyle unless the screws cause lameness during exercise, the distal screw is less than 1 cm from the articular surface, or screws are placed in the diaphysis for repair of long spiral fractures.[2] Many horses are lame after screw fixation because of the development of osteoarthritis or concurrent injuries and not because of the screws.[8] The prognosis for pasture soundness is good in all horses with treated condylar fractures. Horses with complete, displaced lateral condylar fractures have a poor prognosis for racing.[1, 8] However, horses with incomplete lateral condylar fractures repaired either with lag screw fixation or with rest are likely to race.[1, 8]

[h]PDS II, Ethicon, Inc., Somerville NJ.
[i]Prolene, Ethicon, Inc., Somerville, NJ.
[j]Leg saver splint, Kimzey, Inc., Woodland, CA.

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chapter 59

Repair of Fractures of the Proximal Phalanx

Fractures of the proximal phalanx occur most often in horses during races but may occur from other athletic activities or as pasture accidents. Many configurations of these fractures occur, ranging from small osteochondral fractures of the dorsal proximal aspect of the proximal phalanx, which have an excellent prognosis, to heavily comminuted fractures, which create limb instability and a threat to life regardless of treatment. Fractures of the shaft of the proximal phalanx usually propagate in a sagittal plane from the middle sagittal groove of the proximal articular surface.

Major fractures of the shaft of the proximal phalanx may be classified for purposes of treatment as noncomminuted sagittal fractures and comminuted fractures. Excluding the small osteochondral "chip" fractures, sagittal fractures are the most common type of proximal phalangeal fracture in racehorses. Sagittal fractures may be incomplete or complete. Short and long incomplete sagittal fractures have been managed successfully with bandaging and stall rest and with lag screw fixation.[1–3] The success of the two methods for returning horses with incomplete fractures to racing appears to be similar.[1, 2, 4] In one report, Standardbreds with incomplete midsagittal fractures treated with rest or with surgery had a favorable prognosis for return to racing, but they had slower race times and decreased performance indexes after injury regardless of the method of treatment.[4] Lag screw fixation of incomplete fractures may decrease convalescent time by optimizing the conditions for healing of the articular surface[2] and may decrease periosteal reaction on the dorsal surface of the phalanx.[5] By comparison, horses with complete nondisplaced fractures treated conservatively are unlikely to race.[1] Displaced fractures disrupt the articular surface of the fetlock joint and predispose to osteoarthritis. Although healing usually occurs, chronic lameness often follows conservative therapy. Complete sagittal fractures should be treated with lag screw fixation if an athletic future is intended.

Comminuted fractures of the proximal phalanx are treated with the goal of salvaging the horse for nonathletic use. These fractures are life threatening and a challenge to treat successfully. Internal fixation with lag screws is possible when there is an intact piece (strut) of bone spanning the fetlock and pastern joints, the fracture is closed, and the articular surface of the fetlock joint can be reconstructed.[3, 5] A short-limb cast should be applied after internal fixation. Severely comminuted fractures that cannot be treated with lag screws may be treated with full-limb casts. However, collapse of the fractured phalanx within the cast, cast sores, delayed healing, chronic pain, and breakdown of the opposite limb lead to poor success for cases treated with full-limb casts. Transfixation casting to improve fracture stability is preferable to casting alone for severely comminuted fractures.[3, 6] Alternatively, an external skeletal fixator[a] is available; it transfers weight from the metacarpus or metatarsus to the ground.[7]

Anesthesia, Positioning, and Surgical Preparation

For first aid, the limbs of horses with incomplete sagittal fractures can be wrapped in heavily padded bandages. Limbs with unstable fractures should be immobilized with a cast applied so that the cannon bone and phalanges are in a straight line, or with a commercial aluminum orthopedic splint.[b] Before surgery, pain should be controlled as needed with analgesics. Intravenous perioperative antibiotics are given to all horses undergoing internal or external fixation of proximal phalangeal fractures. Antibiotics are continued for 5 days in horses with comminuted fractures, or longer when the fracture is open.

Horses are anesthetized and positioned in lateral recumbency; the affected limb is positioned so that the lag screws are placed from the uppermost side of the limb. Usually the lateral side of the limb is uppermost because the lateral aspect of the fracture is most frequently drilled for the gliding hole, and the intact strut in comminuted fractures is usually medial.[1] Hair is re-

[a]Equine external fixator, Gauthier Medical Inc., Rochester, MN.
[b]Kimzey leg saver splint, Kimzey, Inc., Woodland, CA.

moved from the coronary band to the proximal cannon region, and a routine surgical preparation is done. The limb is draped so that all aspects of the proximal phalanx are accessible for manipulation during surgery and the fetlock and pastern joints can be visualized to aid positioning of the screws. We place a plastic adhesive barrier drape[c] around the lower limb to allow visualization. A tourniquet is helpful in controlling hemorrhage and can be applied just before surgery. Sterile skin staples can be inserted in a linear pattern over the proximal phalanx every 2 cm to be used as radiographic markers.[3]

Bone screws and equipment for insertion of the screws with a lag screw technique[d] and casting material will be needed for fracture repair. Equipment for intraoperative radiography should be available.

Surgery

Repair of Nondisplaced Sagittal Fractures

Incomplete and complete nondisplaced sagittal fractures can be repaired with 4.5- or 5.5-mm cortical screws inserted with a lag technique through stab incisions. The 4.5-mm screws are usually adequate for repair. The technique for insertion of cortical bone screws with a lag screw technique is given in detail in Chapter 56. The extensor branches of the suspensory ligament, the extensor tendons, the proximal tuberosities and distal eminences of the proximal phalanx, and the distal sesamoidian ligaments serve as landmarks for placement of the screws.[8] The proper locations can be confirmed with assistance from intraoperative radiographs and preplaced sterile skin staples or with a fluoroscope.

The first screw is inserted just below the proximal articular surface of the proximal phalanx but must not impinge on the sagittal groove. The point for insertion of the first screw is dorsal to the extensor branch of the suspensory ligament at a level just distal to the palpable proximal tuberosity of the phalanx (Fig. 59–1*A*). A 1-cm-long incision down to the bone and parallel to the extensor branch is made with a scalpel blade. Drilling is done perpendicular to the long axis of the limb and perpendicular to the sagittal axis of the fracture. All drilling and tapping should be done through guides to prevent entrapment of soft tissues in the drill bits and tap. The location of the hole can be maintained during the exchange of instruments by a small bone pin, which is inserted into the hole between steps.[3] The gliding hole must cross the fracture fissure. Careful intraoperative measurements with a ruler or intraoperative radiographs can confirm that this step is correct. The thread hole should be drilled completely through the far cortex. This will ensure adequate purchase of the screw when it engages the far cortex during insertion. Countersinking the near cortex is necessary because the cortex is curved and not perpendicular to the screw. The screw is inserted and tightened after measuring the hole depth and tapping. The screwdriver can be left on the first screw as a guide for insertion of subsequent screws.

The second screw is inserted 2 cm distal to the first screw. A 1-cm-long incision just below and palmar or plantar to the extensor branch of the suspensory ligament is made down to the bone. The second screw is inserted in the same manner as the first screw and is usually parallel to the first screw. Additional screws are inserted 2 cm apart for the length of the fracture. Screws should not be inserted below the level of the fracture fissure as identified by radiographs. The fracture line may spiral in the distal aspect of the phalanx, and blindly placed screws may enter a fracture fissure.

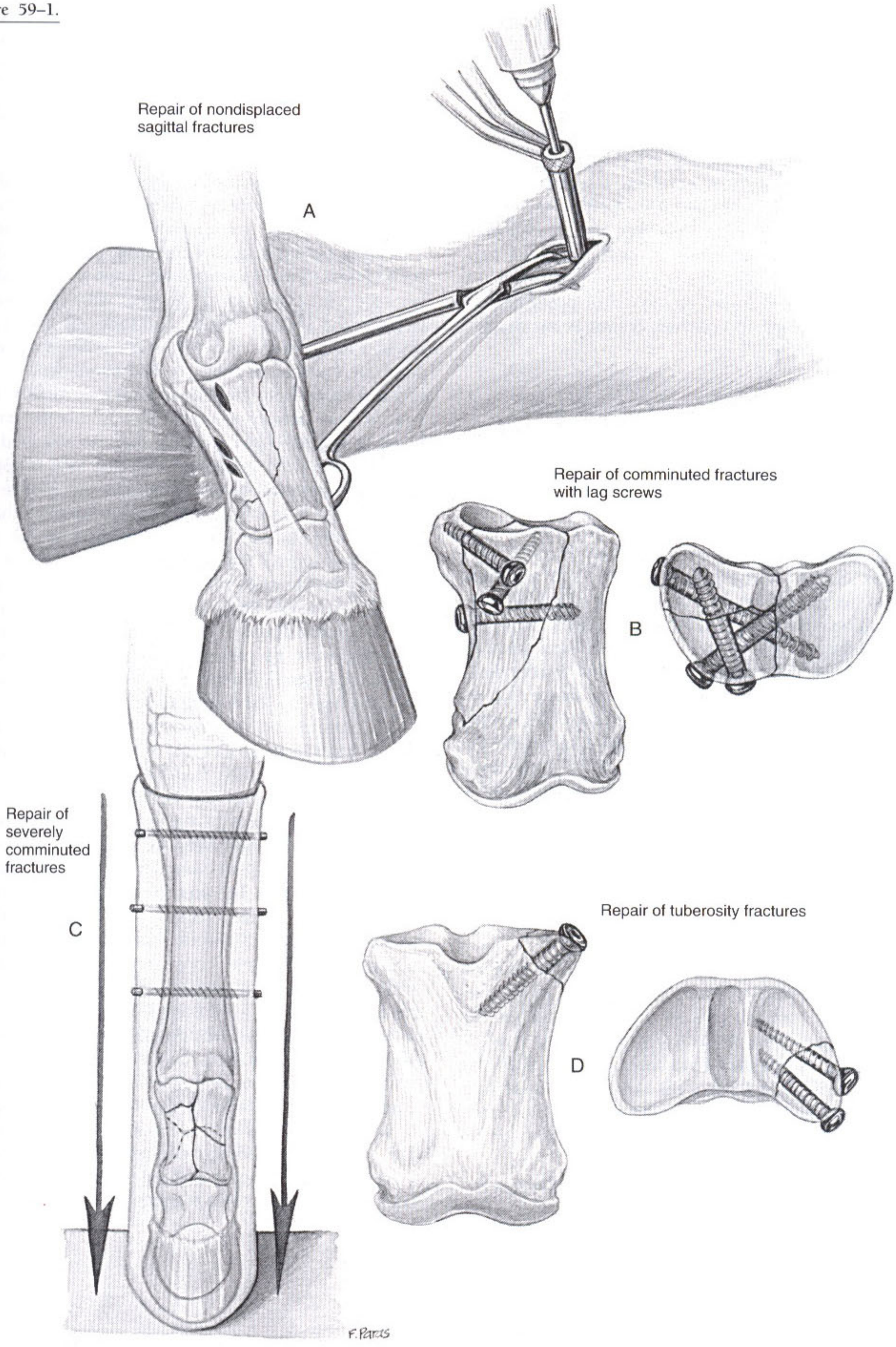
Intraoperative images are taken to ensure that the screws are positioned properly, the glide holes cross the fracture, and all screws engage the far cortex. The stab incisions are closed by suturing the skin with monofilament nonabsorbable suture material in a simple interrupted pattern. A sterile wound pad is applied. Horses with incomplete sagittal fractures of the forelimb can recover from anesthesia safely in a heavily padded bandage. A half-limb cast incorporating the foot should be applied to horses with complete fractures of the forelimb and all fractures of the hindlimb for recovery from anesthesia. An alternative to cast application is the use of a plastic compression boot[e] or an aluminum orthopedic splint for recovery from anesthesia.[3]

Repair of Displaced Sagittal Fractures

A 2-cm-long arthrotomy incision, extending through the extensor tendons, is made directly into the dorsal proximal aspect of the fracture fissure and into the fetlock joint. This incision is used to visualize and align the articular surface as the fracture is reduced and to clean out the fracture gap.[3] Older fractures may require that the incision be extended along the length of the fracture fissure to facilitate removal of blood, fibrous tissue, and small fracture fragments, which prevent reduction of the fracture. The fracture is reduced and stabilized with two ASIF large, pointed reduction forceps.[f] Fracture fixation is performed using the same method described for nondisplaced sagittal fractures. All horses should recover from anesthesia in a half-limb cast incorporating the foot.

[c]Ioban 2, Animal Care Products, 3M Health Care, St. Paul, MN.
[d]ASIF instruments and implants, Synthes (USA), Paoli, PA.
[e]Farley compression boot, Equine Orthotics, Inc., Indian Harbour Beach, FL.
[f]ASIF reduction forceps, Synthes (USA), Paoli, PA.

Figure 59–1.


Repair of nondisplaced sagittal fractures
A
Repair of comminuted fractures with lag screws
B
Repair of severely comminuted fractures
C
Repair of tuberosity fractures
D
F. Parcs

Repair of Comminuted Fractures with Internal Fixation

These fractures are repaired using lag screws to attach smaller pieces to the intact strut of bone that spans the fetlock and pastern joints (Fig. 59–1*B*). The fetlock joint should be reconstructed as well as possible; therefore, the joint is opened and visualized during fracture repair. Richardson[3] described an abaxially curved flap incision with severance of the collateral sesamoid ligament, collateral ligament, and joint capsule. This approach provides maximum joint exposure and may result in a lower incidence of postoperative infection than other approaches. A cast is maintained on the limb for 6 to 12 weeks.

Repair of Severely Comminuted Fractures with External Fixation

Severely comminuted fractures are extremely unstable. Internal fixation may not be indicated, and casting alone does not provide good stability. Fractures may collapse within a cast as the metacarpus or metatarsus displaces distally. Horses in short-limb casts are more prone to this complication than those in full-limb casts. Transfixation casts have been shown to provide superior axial stability for unstable proximal phalanx fractures compared with short-limb casts.[6] External fixation with transfixation casts or an external skeletal fixator may be the best means to salvage horses that cannot be treated with internal fixation because of severe comminution or open wounds. We prefer transfixation casts using 1/4-inch core diameter pins with 5/16-inch positive profile central threads[8] (Fig. 59–1*C*). The technique for application of the transfixation cast is described in Chapter 64.

Lag Screw Fixation of Palmar/Plantar Tuberosity Fractures

These fractures can be stabilized by the insertion of one or two cortical screws using the lag technique. Two 3.5-mm cortical screws are preferable in the smaller fractures (Fig. 59–1*D*). An arthrotomy may be done to reduce displaced fractures and to align the fragments. These fractures must not be confused with ununited proximoplantar tuberosities in the hind limbs of young Standardbred horses. Many ununited proximoplantar tuberosities will unite to the phalanx after 6 to 12 months of rest and do not require surgical treatment.[9]

[8]Large-animal transfixation casting pins, IMEX Veterinary, Inc., Longview, TX.

Postoperative Management

For sagittal fractures repaired with internal fixation, the cast can be either removed immediately after complete recovery from anesthesia or left in place for 3 to 5 days. For all sagittal fractures, a bandage should be maintained for 3 weeks after surgery. Horses should be rested in a stall for 2 months, with hand-walking exercise the second month. Paddock rest for an additional 1 to 3 months, depending on radiographic evaluation of fracture healing, is recommended. A small lucency adjacent to the fetlock joint may remain. However, if the lucency remains after 5 months and the horse is sound, light training can be resumed. The average time from fracture to the first race is approximately 7 months for horses with short, incomplete sagittal fractures; 9 months for complete fractures that extend to the lateral cortex; 10 months for long, incomplete sagittal fractures; and 12 months for complete sagittal fractures that extend into the pastern joint.[2] Between 52% and 88% of horses with noncomminuted sagittal fractures race.[1, 2, 4, 10] Horses with complete fractures that enter the pastern joint carry a poor prognosis for racing. Standardbreds with incomplete midsagittal fractures have the best prognosis.[4]

Comminuted fractures treated with lag screws should remain in a cast for at least 4 to 6 weeks, or longer when healing is delayed. Nonsteroidal anti-inflammatory drugs should be given as needed. Strict stall rest with support of the opposite limb is recommended. Horses often bear excessive weight on the opposite limb, so frog support and fetlock support should be provided. The pins used for transfixation casts or the external skeletal fixator may be left within the bone for up to 9 or 10 weeks, although many pins will loosen before this time. Loose pins should be removed. After pin removal, casting may be required for an additional 4 to 6 weeks. The complications for horses with comminuted fractures include infection, cast sores, lysis around transfixation pins, laminitis and tendon breakdown of the opposite limb, chronic lameness from osteoarthritis, and collapse of the fracture. The prognosis for survival of horses with comminuted fractures treated with internal fixation approaches 60%.[11] Horses with severely comminuted fractures treated with external fixation have the poorest prognosis for survival.[7]

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chapter 60

Excision of Apical Fractures of the Proximal Sesamoid Bone

Excision of apical fractures of the proximal sesamoid bone is the best method of treatment for horses intended to be used for athletic performance.[1–4] The prognosis after surgery is superior to that for stall rest alone.[2] Generally, fractures that are one third or less of the length of the sesamoid bone from proximal to distal are suitable for excision (Fig. 60–1). Apical fractures may be removed via arthrotomy or arthroscopy. The choice of surgical technique does not affect the prognosis for racing soundness.[4] Small apical fractures are easily removed arthroscopically. Larger apical fractures with more extensive attachment of the suspensory ligament are more easily dissected free and removed via arthrotomy. The disadvantages of arthrotomy for removal of apical sesamoid bone fractures are few. Dehiscence, marked postoperative pain, restriction of motion, joint stiffness, and limited visualization after arthrotomy of the fetlock joint for apical fracture excision are rarely problems. Horses can be returned to training as early as 4 weeks after surgery. Arthrotomy may also be used to excise abaxial sesamoid fractures and to evaluate and align the articular surface during repair of midbody sesamoid fractures.

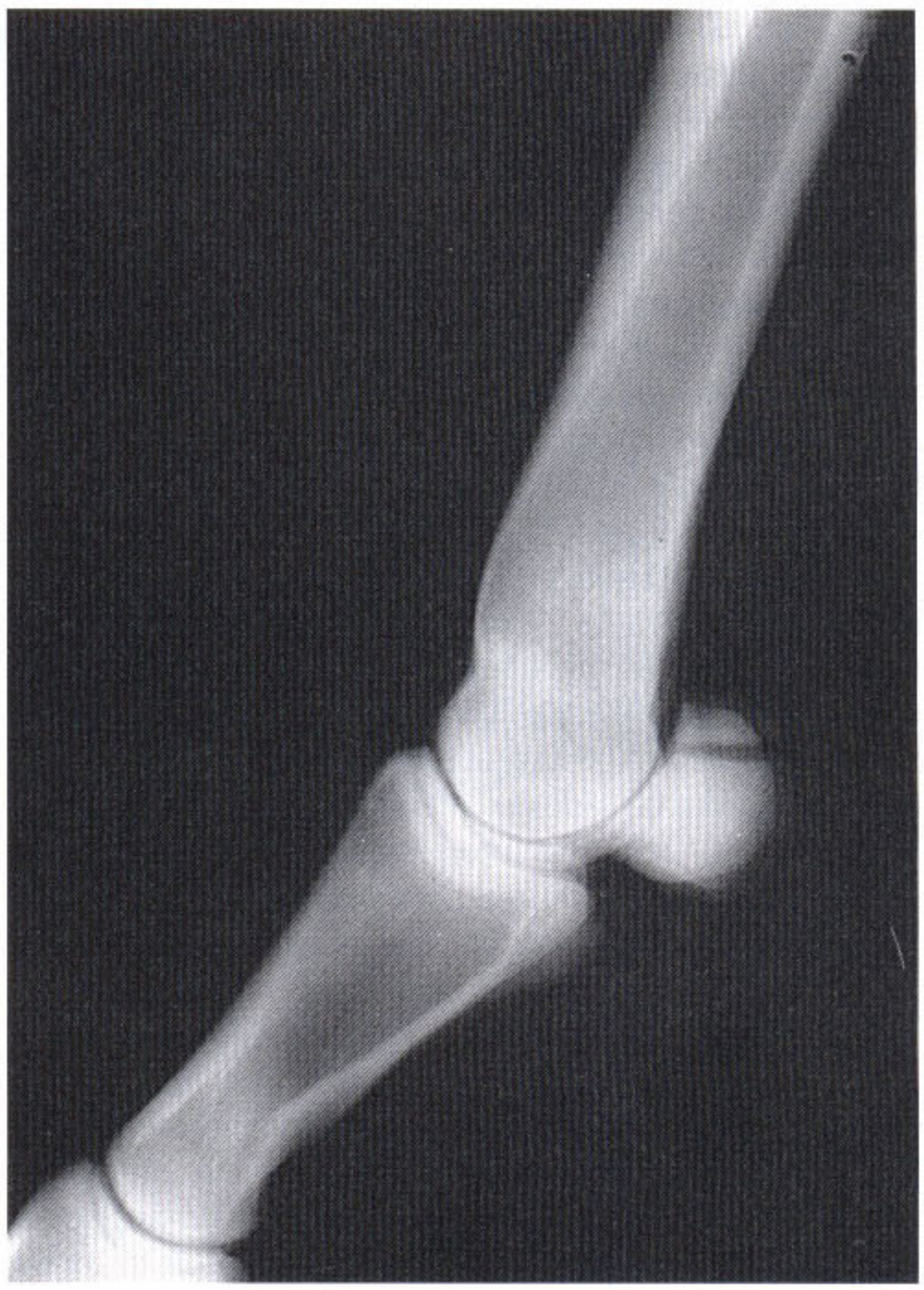


Figure 60–1.

A typical apical fracture of the proximal sesamoid bone that can be treated by excision of the proximal fragment.

Anesthesia, Positioning, and Surgical Preparation

The surgery is performed with the horse anesthetized and placed in lateral recumbency with the fractured sesamoid bone uppermost. Some surgeons prefer the horse to be positioned in dorsal recumbency with the limb suspended. The limb is clipped from the coronary band to the carpus or tarsus and routinely prepared for surgery. Drapes should be impervious. An Esmarch bandage[a] is helpful in controlling hemorrhage in horses positioned in lateral recumbency. A pneumatic tourniquet[b] can be used after placement of the Esmarch bandage when available. We prefer to place the Esmarch bandage before the final skin preparation to reduce chances of contamination of the surgical site.

[a]Esmarch bandage, American Hospital Company, McGaw Park, IL.

[b]Pneumatic tourniquet, Walter Kidde, Mebane, NC.

Surgery

Before making an incision, the surgeon should identify the distal end of the splint bone, the suspensory ligament, the palmar-plantar aspect of the cannon bone, and the apex of the sesamoid bone. A 4-cm skin incision is made starting 1 cm below the end of the splint bone and extending distally. The incision should be in the depression (groove) formed by the back of the cannon bone and the dorsal aspect of the suspensory ligament (Fig. 60–2*A*). The limb is flexed moderately, and the incision is carried through the subcutaneous tissues down to the joint capsule. The joint is entered through a stab incision into the joint made with the scalpel blade (Fig. 60–2*B*). Synovial fluid should escape, confirming entrance into the joint. The incision can then be extended to improve visualization. The fracture site is exposed by fully flexing the fetlock joint. This moves the sesamoid bone proximally into the incision site. The surgeon should avoid incision of the lateral collateral sesamoid ligament. Incision of this ligament to expose the fractured apex of the sesamoid bone is unnecessary when the joint is flexed. Self-retaining Weitlaner or Gelpi retractors are placed into the incision to spread the joint capsule and improve exposure of the apical sesamoid bone fracture.

When the articular cartilage is intact at the fracture site, the location is found with a probe and the cartilage is divided with a scalpel blade or small osteotome. Excision of the apical fracture starts by sharply cutting the fibers of the suspensory ligament on the apical and abaxial sides of the fragment with a scalpel blade (Fig. 60–2*C*). The intersesamoid ligament is then incised with sharply curved Mayo scissors by staying close to the apical fragment. One may also use a sharp double-edged tendon-splitting knife,[a] modified by bending it so it curves around the apical fragment, or a curved McIlwraith sharp osteotome.[b] The apical fragment is grasped with a rongeur and removed by twisting the rongeur in several complete circles to break the remaining soft tissue attachments on the palmar-planter side of the apical fragment, which are difficult to incise (Fig. 60–2*D*). The ligamentous defect that remains usually requires no or minimal trimming. The articular edge of the remaining sesamoid bone should be checked for smoothness. Rough edges, if present, can be removed with a small curet or bone rasp. The joint should be lavaged thoroughly with sterile solution before closure.

A three-layer closure of the incision is performed. Good tailoring is important to protect the integrity of the joint and optimize healing. The joint capsule is closed with size 2–0 absorbable synthetic suture material placed in a simple interrupted pattern. Sutures should be placed no more than 5 mm apart. Preplacement of the sutures before tying the knots may aid in accurate apposition of the tissues. The integrity of the joint capsule closure may be checked by filling the joint with sterile fluid using a 20-gauge needle. Any leaks in the capsule may be closed with additional sutures. The subcutaneous tissues are closed with a simple continuous pattern using 2–0 synthetic absorbable suture material. Skin closure is performed using a monofilament nonabsorbable suture material placed with any acceptable pattern. We prefer a simple continuous or simple interrupted pattern.

[a]Tendon splitter, Jorgensen Laboratories, Inc., Loveland, CO.

[b]McIlwraith curved osteotome, Sontec Instruments, Englewood, CO.

Postoperative Management

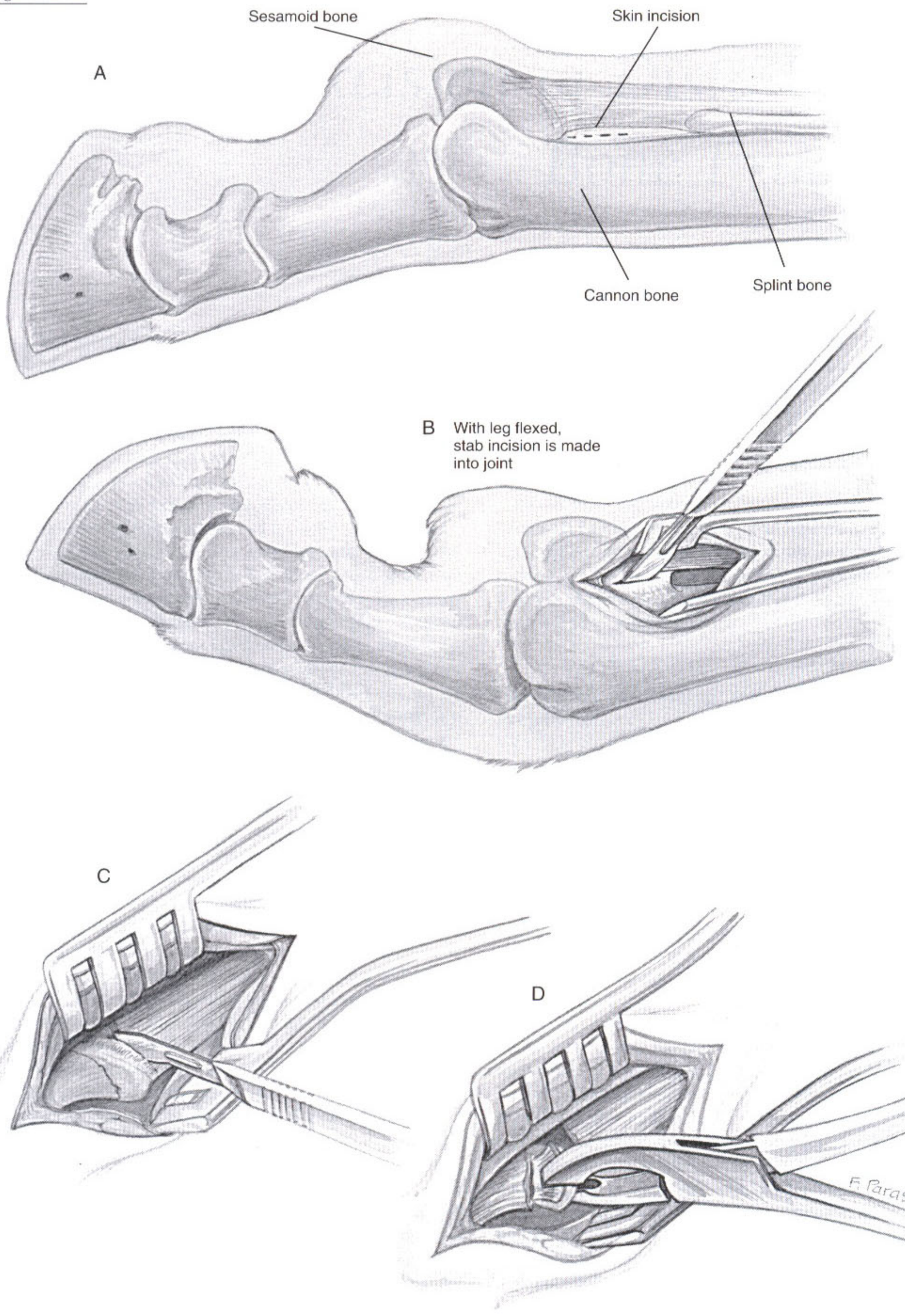
Postoperative radiographs may be taken after surgery to ensure correct removal of the fragment. A nonstick sterile wound pad is placed over the incision, and the limb is bandaged. The bandage should be maintained for 3 weeks and changed every 2 to 3 days or more frequently if it becomes dirty, displaced, or wet. Stall rest with short periods of hand walking should be done for the first 2 weeks. Light training can resume 3 to 4 weeks after surgery if no concurrent suspensory ligament damage is present. Training of horses for racing has a strengthening effect on the suspensory ligament. In trained horses, the weakest point in the suspensory apparatus is the sesamoid bones.[5] Early retraining helps to maintain suspensory strength after surgery. Rest periods of up to 6 months may be indicated if suspensory ligament damage is substantial. The suspensory ligament can be evaluated clinically and with ultrasonography.

The prognosis for return to performance soundness in horses after excision of small apical fragments is good.[1, 4] Horses undergoing surgery within 30 days of injury have a better prognosis than those undergoing surgery after 30 days.[1] Horses that have raced before surgery are more apt to race after surgery than horses that have never raced.[1, 4]

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Figure 60–2.


Sesamoid bone
Skin incision
A
Cannon bone
Splint bone
B With leg flexed, stab incision is made into joint
C
D
F. Paras

chapter 61

Excision of Distal Splint Bone Fractures

Fractures of the distal splint bones are most common in performance horses. Thoroughbreds racing counterclockwise have a predilection for fracture of the distal left fourth metacarpal bone or the distal right second metacarpal bone, suggesting increased loading or compression as a causative factor.[1] Racing Standardbreds have a predilection for fracture of the distal left second metatarsal bone or the distal right fourth metatarsal bone, suggesting tension as a contributing factor.[1, 2] These fractures occur during exercise and involve the distal, unattached portion of the bone. More than one splint bone is frequently involved in both Thoroughbreds and Standardbreds.[2] A high percentage of these racing fractures are associated with suspensory desmitis, the involvement of which may affect the selection of candidates for surgery and the prognosis for future racing.[1] Weak, overextended suspensory ligaments are related to the occurrence of distal splint bone fractures.[3] The short ligament that attaches the distal knob of the splint bone to the suspensory apparatus may be stronger than the bone itself. Hyperextension increases the tension on the splint bone, resulting in fracture in the narrow distal area of the bone.[3]

The diagnosis of splint bone fracture is based on history, clinical signs, and radiographs. The horse may or may not be lame in-hand at a trot. Examination of the involved limb for an observable or palpable swelling is key to identifying splint fractures. The degree of heat or pain will depend on the time lapse between injury and examination. It is possible to palpate the full extent of the small metacarpal and small metatarsal bones in the normal horse. Any kind of abnormal thickening or tenderness along these bones warrants radiographic evaluation. The occasional horse, the Standardbred in particular, sustains so much thickening in the cannon region that the distal splint bones may not be palpable; radiographs are essential for determining the presence or absence of fractures in such cases. Four radiographic positions should be used to evaluate the splint bones in horses: dorsopalmar-plantar, lateromedial, dorsolateral-palmaromedial oblique, and dorsomedial-palmarolateral oblique.

Splint bone fractures can precede or follow the development of suspensory desmitis.[4] In racehorses, fetlock diseases, such as proximal sesamoiditis, are present in about one third of the cases with distal splint bone fractures.[1] A thorough evaluation of the suspensory ligament, by palpation and ultrasonography, and assessment of other possible causes for lameness in the affected limb are important in selecting candidates for resection of the distal splint bone fragment. Some splint bone fractures heal, with or without evident callus formation, and do not require surgery. Other cases develop a large, reactive callus at the fracture site and benefit from surgical intervention.

Anesthesia, Positioning, and Surgical Preparation

Because of the associated soft tissue injury, horses with splint bone fractures usually have edema and inflammation in the limb. We apply a padded bandage to the limb for 24 to 72 hours before surgery. This reduces the edema, facilitating evaluation of the suspensory ligament and the splint bone. Although distal splint bone fragments have been resected in the standing horse using chemical restraint and local anesthesia, this approach is not recommended.[4] General anesthesia facilitates convenient positioning of the horse for aseptic surgery. If a single bone is involved, the horse is positioned in lateral recumbency with the affected side up. If more than one bone or limb are involved, dorsal recumbency with the affected limbs suspended permits surgery without needing to reposition the horse. Suspension of the limb aids hemostasis as well, creating a bloodless field for dissection. The hair is removed from the coronet to just above the carpus or tarsus, and the surgical site is routinely prepared for aseptic surgery. Shaving is optional, but incision through skin that has been only clipped leaves short bristles of hair in the tissues. In addition to the loosened distal fragment, and depending on periosteal and interosseous ligament involvement, 1 to 4 cm of splint bone proximal to the

fracture is removed. The operative site needs to be prepared and draped to provide access to nearly the full length of the affected bone. Some surgeons prefer to use a tourniquet for this surgery. We control intraoperative bleeding with electrocoagulation, pressure, and, occasionally, ligation and do not use a tourniquet. In the absence of an open wound or sequestration this is clean surgery, and perioperative antibiotics are unnecessary.

Surgery

A skin incision, starting 1 cm distal to the distal end of the bone and extending 3 to 5 cm proximal to the fracture fissure, is made directly over the splint bone (Fig. 61–1*A*). The subcutaneous tissues are incised to expose the distal fragment of splint bone. In the absence of excessive scar tissue, Metzenbaum scissors can be used for this step. In chronic cases, the splint bone may be enveloped in thick, dense scar tissue that must be incised with a scalpel. Severed vessels can retract into the scar tissue, making it difficult to apply hemostats. Hemorrhage is usually mild to moderate and can be controlled with pressure and suction.

Heavy Mayo scissors and a periosteal elevator are helpful for elevating the scar tissue from the involved bone. The suspensory ligament and, in the case of the fourth metatarsal bone, the great metatarsal artery are adjacent to the bone fragment and should not be damaged by the dissection. Once the fragment is exposed, Mayo scissors are used to cut the ligament that attaches to the distal end of the splint bone (Fig. 61–1*B*). This frees the distal end, and the surgeon can begin to elevate the fractured fragment of splint bone from the cannon bone. A curved bone chisel or gouge[a] is placed under the fragment and forced proximally, severing the interosseous ligament in the process (Fig. 61–1*C*). Sometimes, a sharp instrument can be "pushed" through the interosseous tissue. Occasionally, hitting the gouge with the palm of the hand provides sufficient force to separate the fragment from the cannon bone. When the scar tissue or callus formation is extensive, a mallet will be necessary to advance the gouge and lift the fragment. The gouge is advanced proximal to the fracture site until normal interosseous ligament and unaffected bone are reached. Using the gouge as an anvil, another chisel is used to sever and remove the distal fragment and fracture site with its periosteum (Fig. 61–1*D*). No effort is made to preserve the periosteum of the involved splint bone. The osteogenic layer of periosteum should be removed when future bone production is to be avoided.[5] Rongeurs[b] and a bone rasp[c] are used to smooth the distal end of the remaining proximal portion of splint bone. Mineralization tends to occur in the interosseous ligament and along the border of the third metacarpal-tarsal bone adjacent to the suspensory ligament. Thickened, mineralized tissue must be removed to prevent irritation to the suspensory ligament.

Interrupted sutures with size 2–0 delayed-absorbable monofilament synthetic material are used to close the subcutaneous tissues. In the absence of excessive preexisting scar tissue, drainage is not necessary. When the surrounding limb is chronically thickened and considerable callus has formed, the tissues are inelastic and appose poorly, and a cavity remains where the distal bone fragment was removed. If the cavity is large and hemostasis questionable, a Penrose drain[d] is placed in the cavity and exits below the distal skin suture. The drain serves as egress only. Good skin apposition is helpful in preventing postoperative infection. We prefer a vertical mattress pattern or dermal-epidermal skin closure for those cases with thickened tissues or when a drain has been used.

[a]Hibbs gouge, Miltex Instrument Company, Inc., Bethpage, NY.

[b]Ruskin rongeurs, Miltex Instrument Company, Inc., Bethpage, NY.

[c]Bone file, Miltex Instrument Company, Inc., Bethpage, NY.

[d]Latex Penrose drain, Baxter Healthcare Corp., Round Lake, IL.

Figure 61–1.

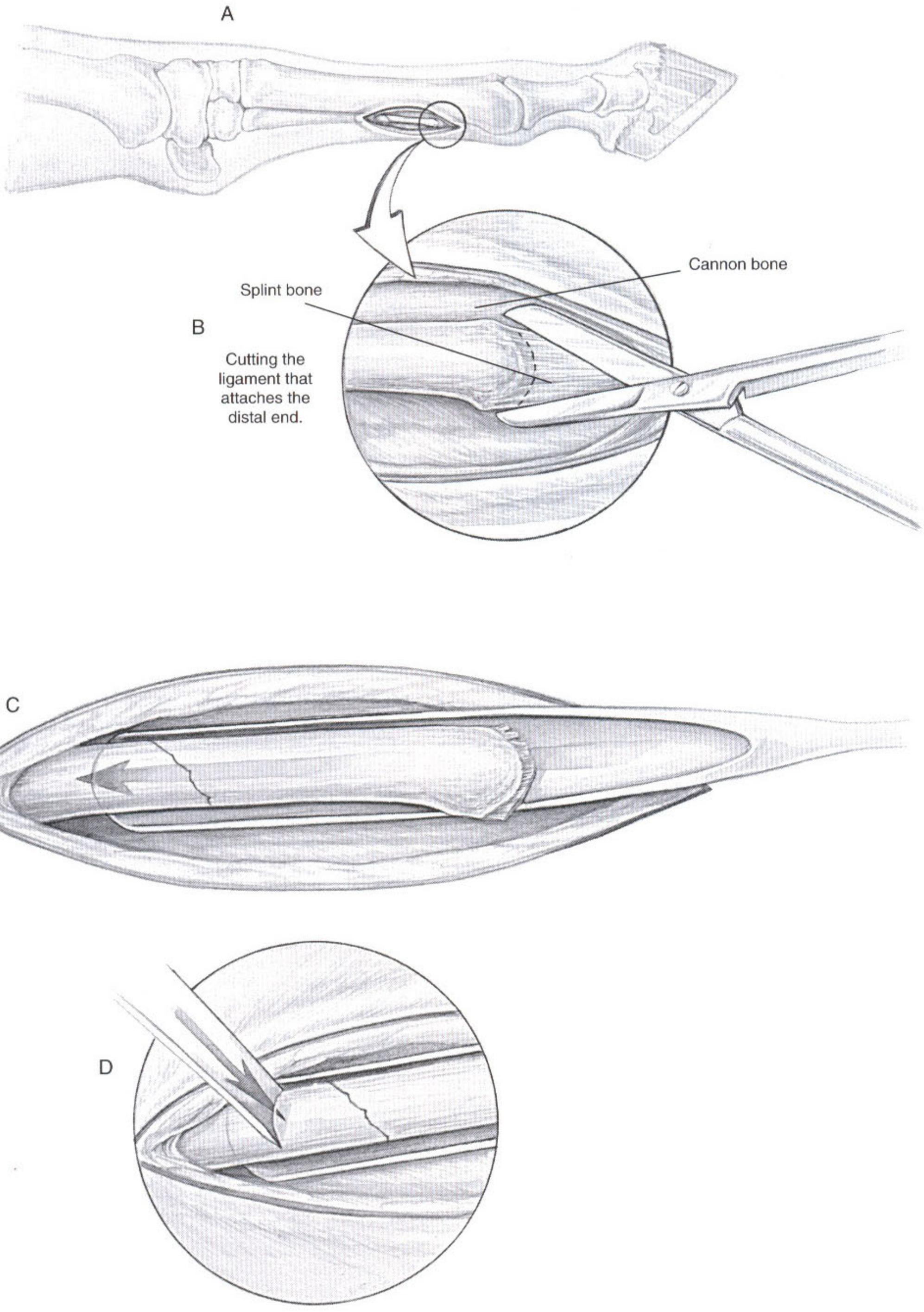

A
Cannon bone
Splint bone
B
Cutting the ligament that attaches the distal end.
C
D



Figure 61–2.

An open proximal fracture of a fourth metatarsal bone with comminution. The injury was managed by surgical debridement and curettage without disturbing the proximal or distal segments of the involved bone.

Postoperative Management

A sterile pressure bandage is maintained on the leg and changed as needed. If a Penrose drain has been used, the bandage is changed daily and the drain removed by 48 hours after surgery. Depending on the degree of suspensory ligament damage, the horse is confined to a stall for 1 to 4 weeks with hand walking thereafter. Nonsteroidal anti-inflammatory therapy is routine, but horses that have sustained a distal splint bone resection are usually bearing weight on the operated limb the day after surgery, even when analgesics have not been administered. Lameness at a walk that persists beyond the third day could be a sign of infection. Other complications are rare. The limb should be bandaged for 4 to 6 weeks. The prognosis for this surgery is good or excellent. The status of the suspensory ligament may have a greater impact on the schedule and return to racing soundness than does the approach to management of the fracture per se.[1, 2, 4] The prognosis for the return of racehorses to their previous level of performance is determined by the preexistence of suspensory desmitis and the manner in which the desmitis is managed.[1, 2, 4]

Proximal fractures of the splint bones occur in all breeds as a result of external trauma. They are frequently associated with osteomyelitis, sequestration, and open, draining wounds (Fig. 61–2). Surgical management of proximal splint fractures with osteomyelitis and sequestration involves a surgical technique similar to that described for distal fractures. The surgeon should be certain to remove all dead bone and infected tissue. Depending on the location and nature of the injury, the distal extremity of splint bone can be removed with the diseased proximal splint bone or left in situ. It may be difficult to decide how to manage the remaining proximal fragment.[6] Screw fixation of the proximal splint to the cannon bone may be ill-advised in the presence of infection.[4] Because of the articulation with the joint above, screw fixation can torque the proximal fragment and cause chronic lameness. In a report of a limited number of cases, plate fixation was more successful than screw fixation.[6] If the ligamentous attachments of the proximal fragment are intact, no fixation is required. Complete excision of the fourth metatarsal bone is possible and can be followed by athletic soundness.[7]

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chapter 62

Osteostixis for Dorsal Cortical Fractures of the Third Metacarpus

Dorsal cortical fractures, or stress fractures of the third metacarpal bone, occur most commonly in 2- to 6-year-old Thoroughbred racehorses.[1] Most horses have a history of dorsal metacarpal bone pain before the fracture.[1] Incomplete dorsal cortical fractures occur predominantly in the dorsolateral cortex of the left third metacarpal bone of Thoroughbred racehorses. These fractures are believed to be caused by high-strain cyclic fatigue, which causes a decrease in bone stiffness.[2] Bone modeling and remodeling are inadequate to protect the bone from fracturing. Radiographically, dorsal cortical fractures usually extend from the dorsal periosteal surface to the middle or inner third of the dorsal cortex in a proximopalmar direction at approximately a 30° angle.[1] The fractures frequently occur at or slightly distal to the mid-diaphysis. Other configurations and locations are possible. Incomplete dorsal cortical fractures are often slow to heal and may remain unchanged radiographically for months.

Surgical techniques that have been developed to encourage and promote healing of these fractures include transcortical lag screw fixation, unicortical lag screw fixation, unicortical fixation combined with drilling holes in the bone around the screw, and drilling holes in the fractured cortex.[2–6] Perforating the cortex with drill holes, termed *osteostixis,* is successful for the treatment of most of these fractures.[2–5] Three to ten drill holes, 2.0 to 3.5 mm in diameter, are placed directly through the fractured dorsal cortex in a uniform diamond-shaped pattern. The holes are thought to stimulate osteogenesis and osteoinduction of bone. The woven bone that fills the drill holes may help stabilize the fracture.[3] The ideal drill hole size is unknown. Drill holes act as stress concentrators and weaken the bone. A comparison of clustered 2.7-mm holes and 3.5-mm holes showed no significant differences in the breaking strength of third metacarpal bones in vitro.[7] However, breaking strength of all drilled bones was approximately 50% of the breaking strength of undrilled bones.[7]

Anesthesia, Positioning, and Surgical Preparation

Horses are anesthetized and positioned in lateral recumbency with the affected limb uppermost. The limb is surgically prepared from just distal to the fetlock to the carpus and draped for aseptic surgery. Sharp orthopedic drill bits, preferably new, and a power drill are recommended for this surgery. Equipment to take intraoperative radiographs or fluoroscopic images should be available.

Surgery

A 6- to 7-cm-long longitudinal incision is made through the skin and subcutaneous tissues centered directly over the palpable, firm swelling created by the fracture. Preoperative radiography can be used to locate the position of the fracture when swelling is minimal. The common digital and lateral digital extensor tendons often need to be retracted medially to expose the fractured dorsal cortex, or the incision can be made between the common and lateral digital extensor tendons. The fractured cortex is identified by the roughened and elevated periosteum. The periosteum is incised and elevated. The fracture line itself is rarely visible.[3] A sharp 2.7-mm drill bit (2.0 to 3.5 mm is acceptable) is seated in a power drill, and the first hole is drilled in the center of the fractured cortex. The hole should be perpendicular to the long axis of the metacarpus and to the surface of the bone and should penetrate to the medullary cavity. The dorsal cortex of the adult equine metacarpal bone is extremely dense and hard. Breakage of drill bits may occur.[3, 4] Breakage can be reduced by (1) using a sharp drill bit, (2) applying moderate, even pressure while drilling, (3) using a drill guide, (4) lubricating the drill bit with saline, and (5) using a power drill with a high speed. Removal of the bit to clean the flutes once or twice while drilling each hole also helps to prevent breakage and reduces heat damage. The drill bit is left in the first hole, and intraoperative images are taken perpendicular to the bit to determine the exact position. Using the location of the first hole as a reference point, two to nine additional holes are drilled through the dorsal cortex at the fracture site in a diamond-shaped pattern (Fig. 62–1*A*). The number of holes depends on the length of the fracture and surgeon preference. Holes should be 8 to 10 mm apart on center. The pattern of holes should be placed so that the most proximal hole is proximal to the radiographic limit of the fracture (Fig. 62–1*B* and *C*). After all holes are drilled, a final intraoperative radiograph can be taken to ensure that the whole length of the fracture has been drilled.

Subcutaneous tissues are closed with a simple continuous pattern using size 2–0 polydioxanone[a] suture material. Skin is closed routinely using an acceptable pattern with nonabsorbable, noncapillary suture material. A sterile, nonadherent wound pad is placed over the incision, and a heavy limb bandage is applied. Because the bone is weakened by the drill holes, some surgeons recommend recovery of the horse from anesthesia in a half-limb cast.[5] Complete fracture during recovery appears to be uncommon, and although we do not routinely use a cast, we recommend close observation of the horse during recovery and assistance when needed.

Cortical drilling can be performed successfully in the standing horse using regional anesthesia.[8] There is a greater risk of drill bit breakage intraoperatively as a result of horse movement. The larger 3.2-mm-diameter drill bit is recommended if the surgery is performed on the standing horse to reduce the risk of bit breakage.

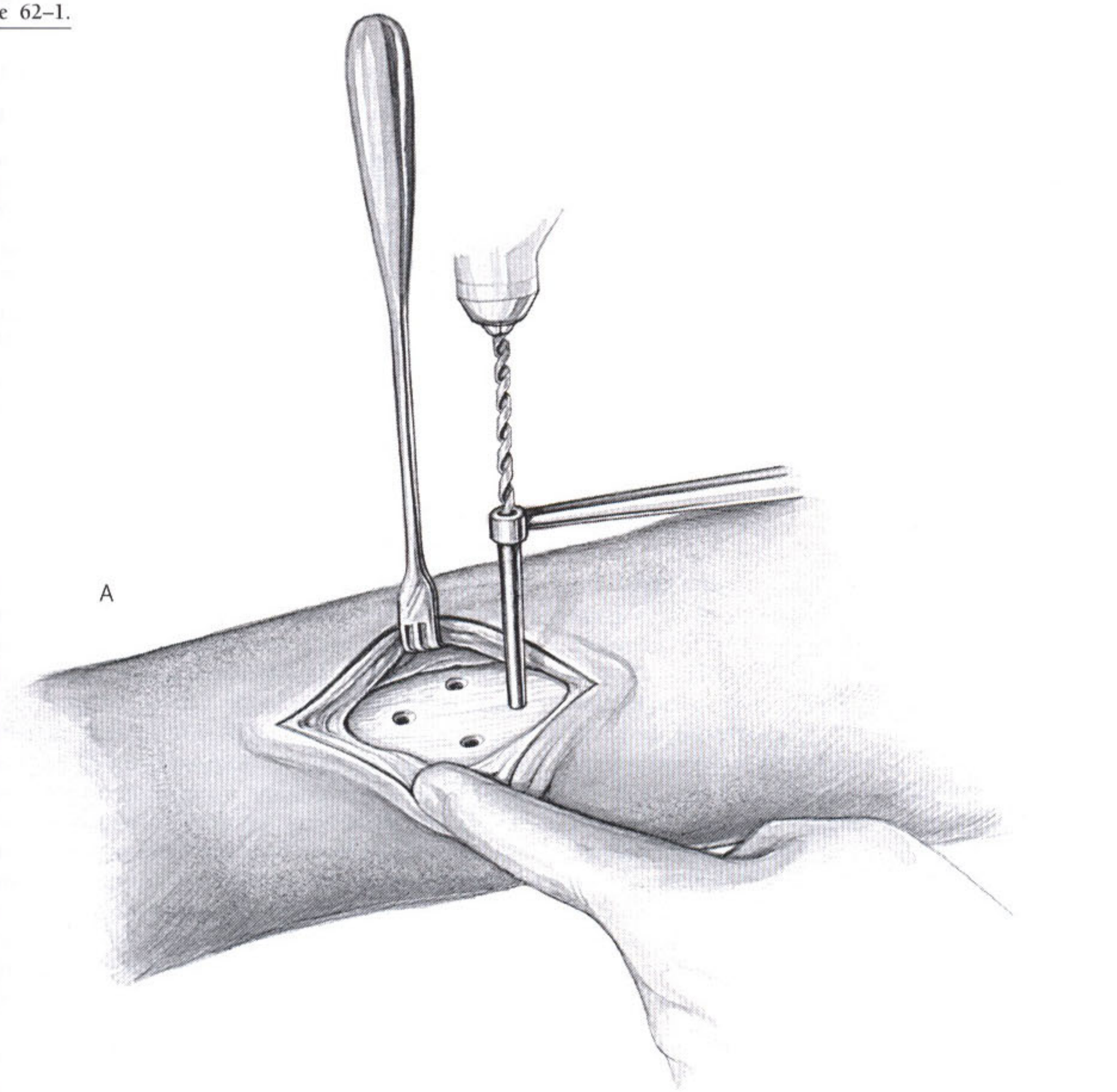
Postoperative Management

Phenylbutazone, 4.4 mg/kg intravenously, is administered to control pain immediately after surgery and is continued if needed for up to 5 days. The bandage is maintained for 4 weeks and changed every 3 to 4 days. Horses should be stall-rested for 8 weeks with daily hand walking for 10 to 15 minutes after 4 weeks. Light exercise, such as jogging or paddock turnout, can resume after 8 weeks. Galloping and working at race speed should not resume until the fracture and the drill holes are no longer visible radiographically.[3, 4] Serial radiographs, performed every 2 months, are used to establish healing. Usually, the fracture fissure is not apparent by 3 months after surgery, but drill holes may remain visible for up to 7 months.[3]

Complications related to surgery include drill bit breakage, subcutaneous infections, chronic lameness, and recurrent dorsal cortical fractures. Most horses return to racing. In two separate studies, 9 of 11 horses[3] and 47 of 53 horses[4] undergoing osteostixis for dorsal cortical fractures raced. However, catastrophic failure of the metacarpal bone occurred in three horses that resumed racing.[4] This serious complication should be discussed with trainers. It is unknown whether a longer recovery time would prevent catastrophic failure. Lowering the intensity of training after surgery may allow the modeling and remodeling processes to proceed. However, long-distance slow work may be detrimental to reshaping the third metacarpal bone for racing. Interspersing short intervals at higher speeds with long-distance work should adapt the metacarpal bone to racing speeds.[2] The optimum timing for return to high-speed exercise and racing after osteostixis for dorsal cortical fractures is unknown.[2] Screw fixation combined with cortical drilling should be considered for treatment of fractures that have recurred following drilling alone.[6]

[a]PDS II, Ethicon, Inc., Somerville, NJ.

Figure 62–1.



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chapter 63

Harvesting Cancellous Bone Grafts

Cancellous bone grafting is a routine procedure in equine orthopedic surgery. Grafts are used for fractures, joint arthrodeses, bone cysts, delayed unions, and osteomyelitis in which bone defects, impaired blood supply, or both are present. Bone grafts provide support and stimulate osteogenesis. Cancellous bone grafts provide osteoblasts for osteogenesis; however, up to 90% of osteoblasts do not survive grafting. Cancellous bone grafts are believed to have an osteoinductive effect, presumably by the recruitment of undifferentiated mesenchymal cells in the host tissues. Bone morphogenic protein, one of a series of polypeptide factors that exert multiple effects on cells and are known to stimulate bone growth and differentiation, is transferred with the graft and may be accountable for the osteoinductive effect.[1]

Although allographs are possible in horses, they require special preparation and storage, which is not practical in many equine orthopedic situations. Fresh cancellous autographs are readily available and most effective. Harvesting cancellous bone as a part of a major orthopedic repair or revision requires an additional surgical procedure, may prolong the operative time, and increases the risk of infection and wound morbidity for the patient. However, if a separate surgical team is used to harvest the graft and the recipient site is ready beforehand, time and risk are reduced and immediate imbedment of the grafts optimizes the results. Cancellous chips should not be stored in lavage fluid or allowed to desiccate. Exposure to air or saline solution is harmful to the survival of cells. If a delay between graft harvest and imbedment is unavoidable, the graft is best stored in blood-soaked sponges that are kept warm by tucking them between tissue layers at the donor or recipient site. Small cancellous chips, less than 0.5 mm thick, should be used liberally and should be firmly packed into the recipient site. Successful grafts become invaded with neocapillaries within 48 hours, and there can be radiographic evidence of bone healing by 3 weeks.

When the surgeon anticipates that a graft may be needed, a donor site should be routinely prepared before the procedure. The tuber coxae, sternum, and proximal tibia are suitable for harvesting cancellous bone and, depending on the positioning of the patient (lateral or dorsal recumbency), are accessible. All three donor sites provide an adequate source of cancellous bone. The risks associated with harvesting the bone are small and are outweighed by the advantages of grafting when needed. Graft material from the tibia appears paler and more fatty than material from the other two sites. A rib also has been used as a donor site in the horse, but the volume of graft material is less[2] and rib sites may bleed persistently after surgery.

Anesthesia, Positioning, and Surgical Preparation

The anesthetic and positioning requirements are dictated by the primary orthopedic surgery. Properly monitored inhalation anesthesia and absolute asepsis are essential for virtually all major orthopedic interventions in the horse, including the harvesting of bone grafts. For patients in lateral recumbency, the tuber coxae or tibia is a readily accessible source of cancellous bone.[2, 3] We prefer the tuber coxae. For horses with forelimb fractures, we frequently position the patient in dorsal recumbency with the affected limb suspended. The sternum and proximal tibia are available donor sites for horses in dorsal recumbency.[3–5] The hair is clipped to provide a wide exposure at the intended donor site. The line of incision is shaved. After routine surgical scrub, impervious, antiseptic-impregnated, self-adhering drapes[a] are used, followed by routine corner draping. The use of perioperative antibiotics and other supportive medication is dictated by the primary orthopedic surgery.

[a]Ioban 2, Animal Care Products, 3M Health Care, St. Paul, MN.

Surgery

Tuber Coxae

The ventrocaudal eminence of the tuber coxae is the most prominent landmark. A 6- to 7-cm incision is made directly over the prominence (Fig. 63–1*A*). Direct incision over the bone eliminates invasion of the gluteus medius muscle and its fascial layers,[3] but positions the incision so that it is vulnerable to postoperative trauma.[2, 3] The skin is thick in this region, and sharply incised skin margins are important for good healing. The incision is extended through subcutaneous tissue, panniculus fascia, and the periosteum of the tuber coxae to expose 4 to 5 cm of bone from the ventrocaudal prominence dorsally. A periosteal elevator can be used to expose sufficient bone surface at the prominence and adjacent dorsal gluteal cortex to gain access to cancellous chips without disrupting major surrounding muscles or their attachments (Fig. 63–1*B*). A bone gouge and mallet (Fig. 63–1*C*), a trephine, or, if a small volume of chips is required, a 3/8-inch drill bit can be used to penetrate the cortex and enter the trabecular compartment between the gluteal and pelvic cortices of the wing of the ileum. A 1 × 1-cm or slightly larger cortical defect provides sufficient access to obtain graft material for most procedures. A curet is used to harvest cancellous bone in the quantity needed; one must be careful not to further penetrate and weaken either cortex (Fig. 63–1*D*). After the graft has been harvested, fascial and subcutaneous tissue layers are sutured with size 0 or 2–0 monofilament synthetic delayed-absorbable suture material[b] using a continuous pattern. The skin is sutured with a size 0 nonabsorbable monofilament synthetic material[c] using vertical mattress sutures alternated with size 2–0 simple interrupted sutures. Precise apposition of the thick skin in this region enhances early epithelialization with sealing of the wound. A stent bandage made of several gauze sponges that have been opened and rolled longitudinally is sutured over the incision. No drains are used.

Sternum

The fourth, fifth, and sixth sternebrae are approached directly by an 8- to 10-cm ventral midline incision centered 15 cm rostral to the xiphoid cartilage. More rostral sternebrae can be used, but they are covered with thicker hyaline cartilage and more muscle. The subcutaneous tissues and pectoral fascia are vascular in this region, requiring electrocoagulation to control bleeding. A periosteal elevator or rongeurs[d] can be used to reflect and remove the hyaline cartilage and to identify the sternebrae and expose cancellous bone. A large curet[e] can be used to harvest as much graft as necessary from one or more adjacent sternebrae. Hyaline cartilage marks the boundaries of each sternebra, establishing the limits of curettage and protecting the thoracic cavity from penetration (Fig. 63–1*E*). Cartilage should not be incorporated with the cancellous graft material. The pectoral fascia and subcutaneous tissues are sutured as separate layers with sizes 0 and 2–0 continuous patterns of polydioxanone,[b] respectively. A Penrose drain[f] placed under the pectoral fascia and exiting through a separate stab incision is useful in cases that persistently ooze blood during suturing. The skin is closed with size 2–0 polypropylene[c] using vertical mattress sutures, and a stent bandage is applied.

Proximal Tibia

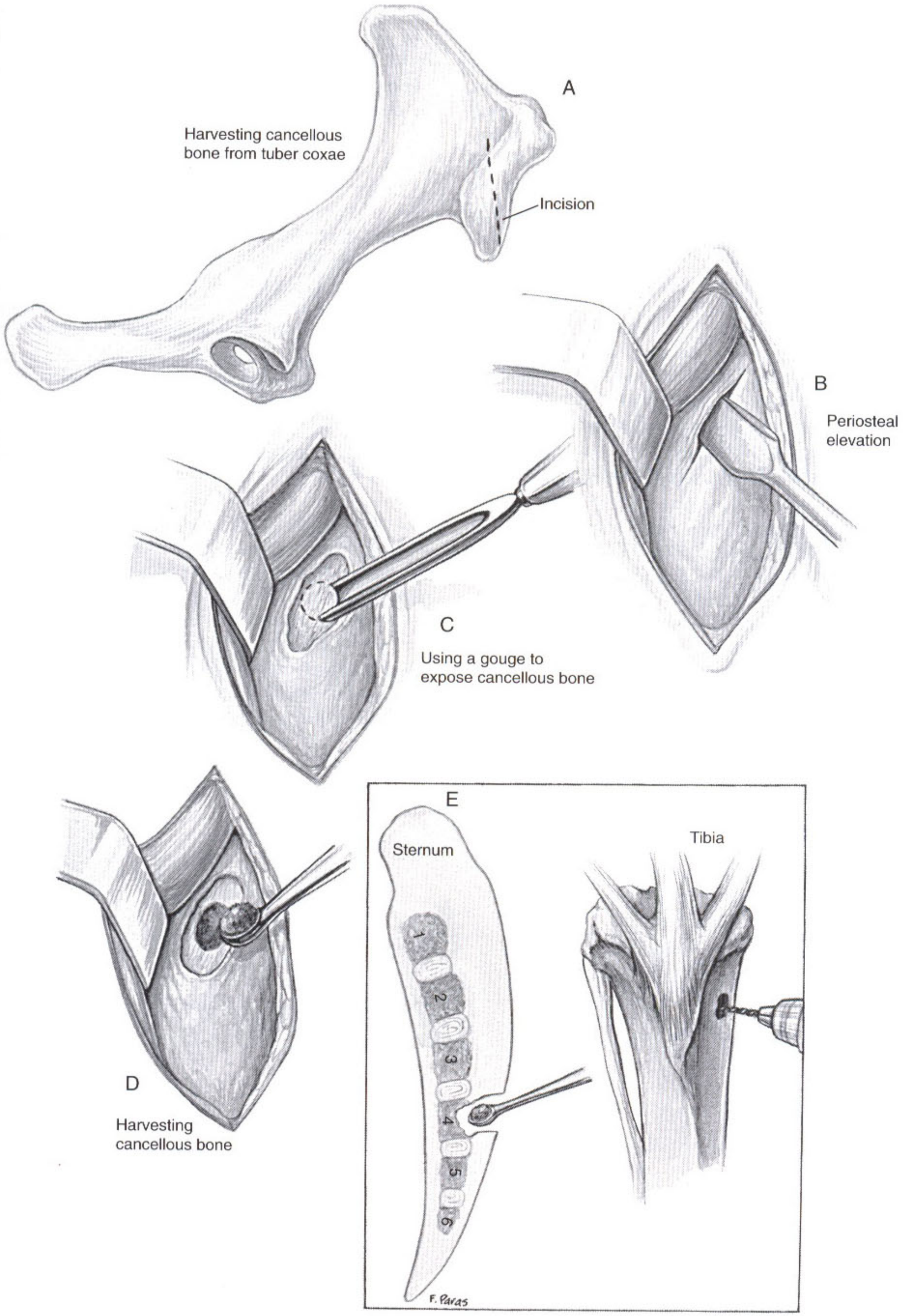
The proximal tibia provides convenient access to cancellous bone with the horse in dorsal or lateral recumbency. A 3- to 5-cm straight incision is made through the skin, subcutaneous tissue, and periosteum over the medial aspect of the tibia, midway between the distal end of the insertion of the middle patellar ligament and the medial border of the bone (see Fig. 63–1*E*). Two 4.5- or 5.5-mm adjacent holes are drilled through the cortex and connected by a "reaming" action to create a 1-cm hole for curet access and graft harvest (see Fig. 63–1*E*). Subcutaneous tissue and skin are sutured in a routine fashion, and a stent bandage is applied. Alternatively, this incision site can be bandaged with elastic adhesive tape, which is tacked to the skin with several interrupted stitches to keep it from slipping down.

Postoperative Management

Medication and patient care are dictated by the primary orthopedic condition for which cancellous bone grafting was used. Antibiotics are unnecessary for the donor site per se. The tuber coxae and sternum sites are vulnerable to trauma and contamination during recovery from anesthesia and in association with recumbency during early convalescence. Some wound morbidity at these donor sites is inevitable. A padded Elizabethan collar may be used to protect the tuber coxae, but such a device is hard to maintain in position. If a Penrose drain has been used, it should be removed

[b]PDS II, Ethicon, Inc., Somerville, NJ.
[c]Prolene, Ethicon, Inc., Somerville, NJ.
[d]Stille-Leur rongeurs, Baxter Healthcare Corp., Round Lake, IL.
[e]Bruns curet, Baxter Healthcare Corp., Round Lake, IL.
[f]Penrose drains, Davol Inc., Cranston, RI.

Figure 63–1.


A
Harvesting cancellous bone from tuber coxae
Incision
B
Periosteal elevation
C
Using a gouge to expose cancellous bone
D
Harvesting cancellous bone
E
Sternum
1
2
3
4
5
6
Tibia
F. Paras

by 24 hours after surgery. Stent bandages are removed by 72 hours.

Peri-incisional edema and serum drainage are frequent complications, particularly with the tuber coxae and sternum sites. It is important to remove particulate matter such as bedding from the incision site, but we are hesitant to scrub or lavage draining incisions; good drainage and air drying are preferable to overmanipulation of the moist skin margins. Fortunately, deep-seated or refractory infections are infrequent. Complete donor site wound dehiscence can follow a difficult anesthetic recovery or prolonged recumbency. Such an event is usually associated with gross wound contamination and should be managed by open wound healing. Fracture of the wing of the ileum is a potential complication with the tuber coxae site. This can be avoided by preserving the gluteal and pelvic cortices when obtaining the bone graft. Tibial fracture is a risk if the proximal cortical portal is greater than 1 cm, and if the cortex is drilled on the dorsal aspect rather than on the medial aspect, as described. If the cortical portal is limited in size and properly positioned, the tibia can be used as a source of cancellous bone without altering the torsional load capacity of the bone or increasing the chance of pathologic fracture.[3, 5] Except for donor site wound problems, the complications from cancellous bone grafting are minimal. The overall advantages of bone grafting as a part of equine osteosynthesis heavily outweigh the disadvantages.

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chapter 64

External Coaptation and Fixation

External coaptation in the form of a cast is commonly used in equine surgery. Fiberglass casts are used for first aid immobilization of orthopedic injuries, as primary treatment for certain luxations and fractures, as reinforcement for internal fixation devices, for support of severed tendons, and as protection for wounds.[1–3] External coaptation must not compromise soft tissues; pressure points must be suitably padded, and the primary vasculature of the encased limb must be protected from thrombosis. When used alone, casts provide only minimal axial stability. For this reason, the articulation proximal to the injury should be incorporated in the cast, or, when necessary, transfixation pins should be used.

Water-activated, polyurethane-impregnated, fiberglass casting tape has replaced plaster of Paris as the standard casting material in equine surgery. Fiberglass is lighter and stronger than plaster of Paris and appears to be more comfortable for the patient. Except when applied to very large animals, longitudinal splints of fiberglass or other rod reinforcements are unnecessary. Fiberglass is porous, aiding drainage from open wounds. It is more radiolucent than plaster, aiding radiographic studies with the cast in place. Fiberglass reaches functional strength within 20 minutes, facilitating a shorter anesthetic period. It does not deteriorate or crumble when exposed to blood or moisture.

Half-Limb Cast

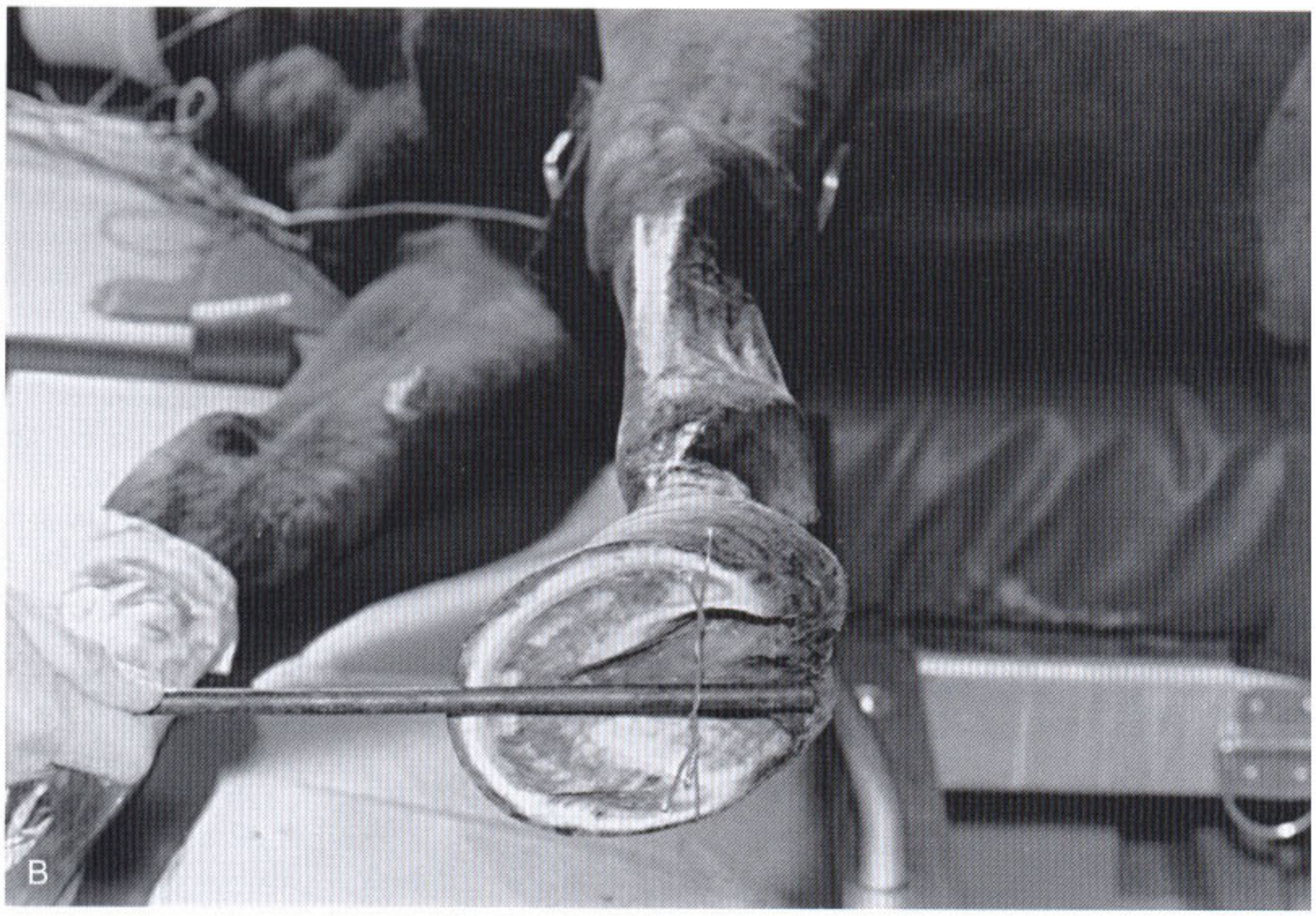
Half-limb casts are the most versatile, most commonly used form of external coaptation in equine surgery. They can be applied to the heavily sedated, standing horse, but many cast applications are supplements to other primary surgical procedures, such as wound debridement or internal fixation of fractures, and the horse is anesthetized. General anesthesia reduces the risk of applying an ill-fitting cast as a result of movement during the application process. Horseshoes are removed, and all four feet are trimmed and properly balanced before cast application to reduce the risk of biomechanical breakdown of the three normal limbs from excess use.

With the horse positioned in lateral recumbency, a bar to extend the foot or to provide traction is applied to the hoof. Starting at the white line, holes are drilled in the hoof wall through both the medial and lateral quarters in a direction similar to driving a horseshoe nail (Fig. 64–1*A*). To extend the foot, wire is threaded through the holes and twisted under the frog. A steel rod inserted under the wires can be used to lever the toe into extension, positioning the foot in a natural weight-bearing posture (Fig. 64–1*B*). Generally, the foot is extended when the limb is cast for immobilization of soft tissues or for support after internal fixation. The appendicular skeleton should be intact and capable of resisting axial compression. If traction is necessary, the wires are fixed to a bar held by an assistant (Fig. 64–1*C*). Traction is used when fractures render the limb unstable and tension is required to align the fragments and hold them in position during application of the cast. For the forelimb, traction should be in alignment with the bony column, and the wires are attached to the quarter and heel region of the foot. For the hindlimb, slight flexion of the interphalangeal joints, to reduce tension on the flexor tendons, is desirable for the best-fitting cast, and the wires are attached slightly dorsal to the widest part of the hoof.



Figure 64–1.

Application of a half-limb cast. *A,* Holes are drilled in the hoof wall.



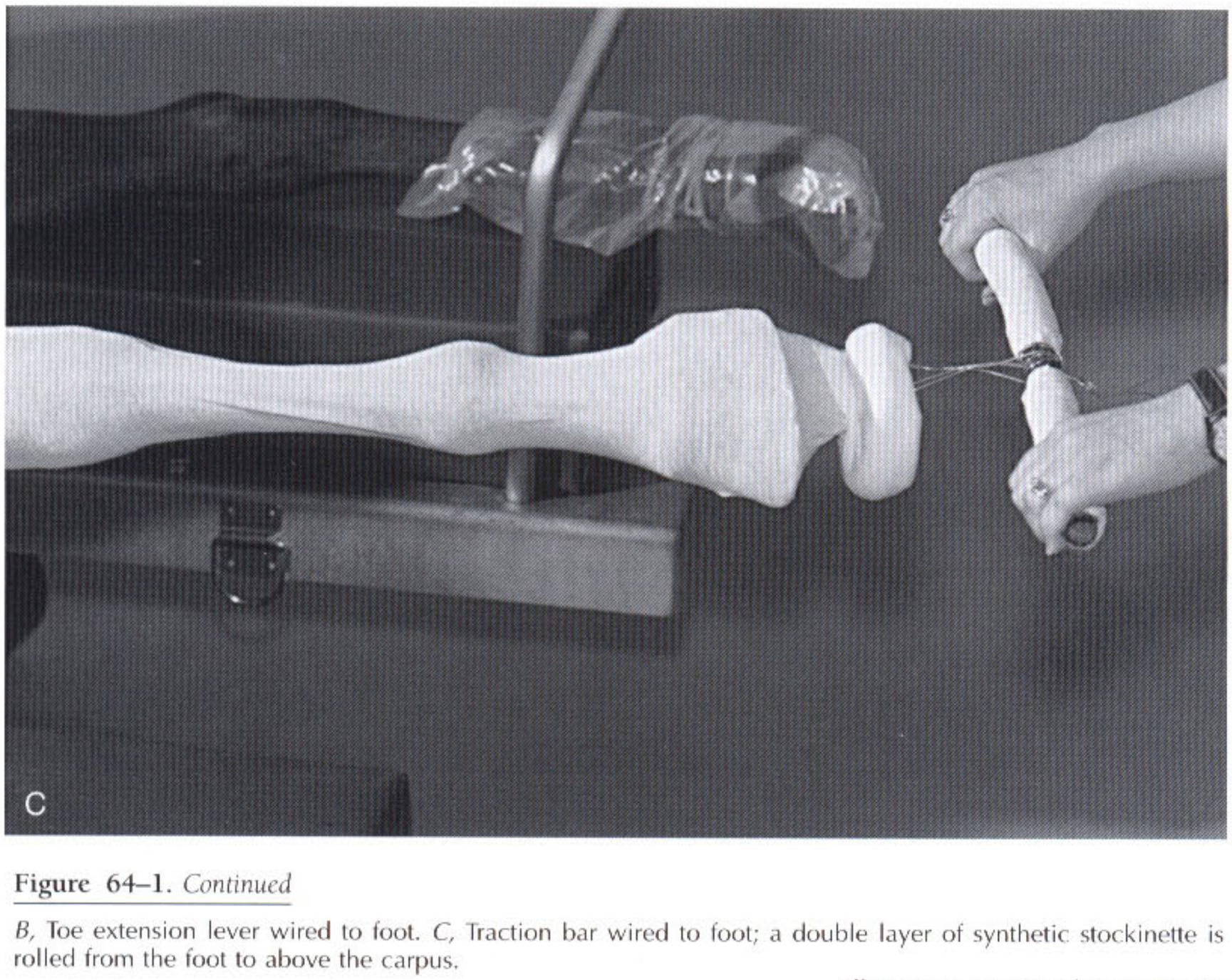


Figure 64–1. *Continued*

B, Toe extension lever wired to foot. *C,* Traction bar wired to foot; a double layer of synthetic stockinette is rolled from the foot to above the carpus.

Illustration continued on page 315

The skin must be clean before the cast is applied. Dirt and manure caked in the hair may cause skin irritation or maceration. Hair should be clipped from the margins of minor wounds, and all wounds or incisions are covered with antiseptic-impregnated sterile dressings. A double layer of synthetic stockinette[a] is rolled from the foot to above the carpus (see Fig. 64–1*C*). Either thin cotton padding[b] or ¼-inch orthopedic felt[c] is used to pad the coronary band region, and a 2-inch wide strip of ¼-inch felt is applied around the metacarpus-metatarsus just distal to the carpus-tarsus. When felt is used at the coronary band, it is split into a half-thickness sheet, and cutouts are made over the bulbs of the heel (Fig. 64–1*D*).

Fiberglass does not contour to the irregularities of the equine limb well enough to be used without padding. Fiberglass casts without padding, or applied over stockinette alone, result in pressure sores. However, excessive felt or cotton padding absorbs sweat and wound discharge, mats down and shifts out of position, and results in a poorly fitting cast. A lightweight, porous, resilient, water-curable foam padding[d] has been specially designed for the horse. This foam padding does not absorb water, creates a close anatomic fit by becoming stiff when covered with fiberglass, and fills the gaps between the fiberglass and the limb. It keeps the coarser fiberglass away from the skin and helps prevent pressure sores. Use of the foam padding entails one very important precaution. When wet, the padding is rather elastic, and there is a temptation to "stretch" the roll as the padding is applied, creating a perfect contour. However, this can create a tourniquet effect on the limb with serious loss of skin.

For the half-limb cast, one roll of 3-inch × 3-yard custom foam padding is adequate. With gloved hands, the surgeon immerses the roll in 70° (room-temperature) water until the air is displaced, squeezes once, and applies it to the limb. Starting at the felt collar below the carpus-tarsus, the surgeon rolls the water-laden foam around the limb with minimal tension from proximal to distal using half-lap spirals. An extra layer of foam is placed around the fetlock. This creates a two-layer padding ½-inch thick with three layers at the fetlock (Fig. 64–1*E*).

[a]Synthetic stockinette, IMEX Veterinary, Inc., Longview, TX.

[b]Sof-Rol cast padding, Johnson & Johnson Professional, Inc., Raynham, MA.

[c]One-quarter-inch felt padding, DePuy Prosource, Jackson, MI.

[d]Custom support foam, Animal Care Products, 3M Health Care, St. Paul, MN.

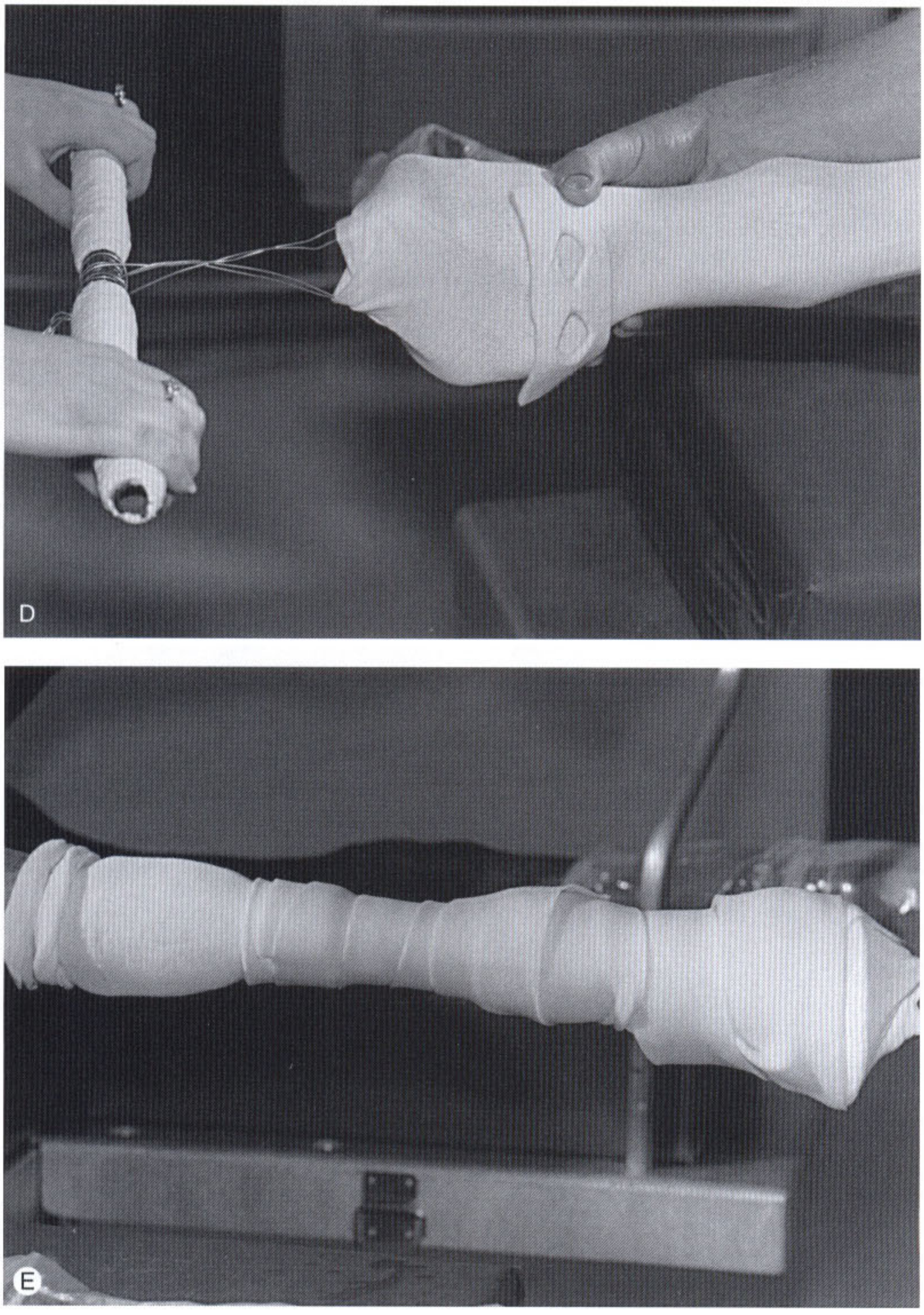


Figure 64–1. *Continued*

D, A 2-inch-wide band of ¼-inch orthopedic felt is applied around the metacarpus just distal to the carpus. A felt pad with cutouts is used to pad the bulbs of the heel. *E,* Custom foam padding is loosely rolled around the limb.

Illustration continued on following page

For the half-limb cast on adult horses, six or seven 4-inch × 4-yard rolls of fiberglass casting tape[e] are used. For foals or smaller horses, 3-inch rolls are useful, and four to six rolls are sufficient. The first roll is applied dry, directly over the water-laden foam padding. The second roll is immersed in water, but no water is squeezed out. Subsequent rolls are immersed in water and squeezed up to three times before application. Initial rolls are started proximally and wrapped distally with one-half to two-thirds overlap. The fetlock and pastern regions are figure-of-eight wrapped for reinforcement, and the wrapping is returned proximally (Fig. 64–1*F*). The amount of water carried into the cast is a judgment based on experience and determines setting time. Excessively wet casts will cure but require more time. Dry casts may laminate and not be sufficiently strong. All layers, including the custom foam, should cure simultaneously, usually within 20 minutes.

When the cast is sufficiently set to hold the foot in position, the toe extension or traction device is removed, and the entire foot is encased in fiberglass. If the foot has been positioned in flexion, a wooden heel wedge can be incorporated into the foot cast to even the weight-bearing surface with the ground (Fig. 64–1*G*). Hard acrylic[f] is applied to the bottom surface to prevent wearing away of the fiberglass during convalescence (Fig. 64–1*H*). The stockinette is rolled over the proximal rim of the cast and taped in place to complete the construction.

[e]Dynacast Extra, Smith & Nephew, Inc., Germantown, WI.

[f]Technovit, Jorgensen Laboratories, Inc., Loveland, CO.

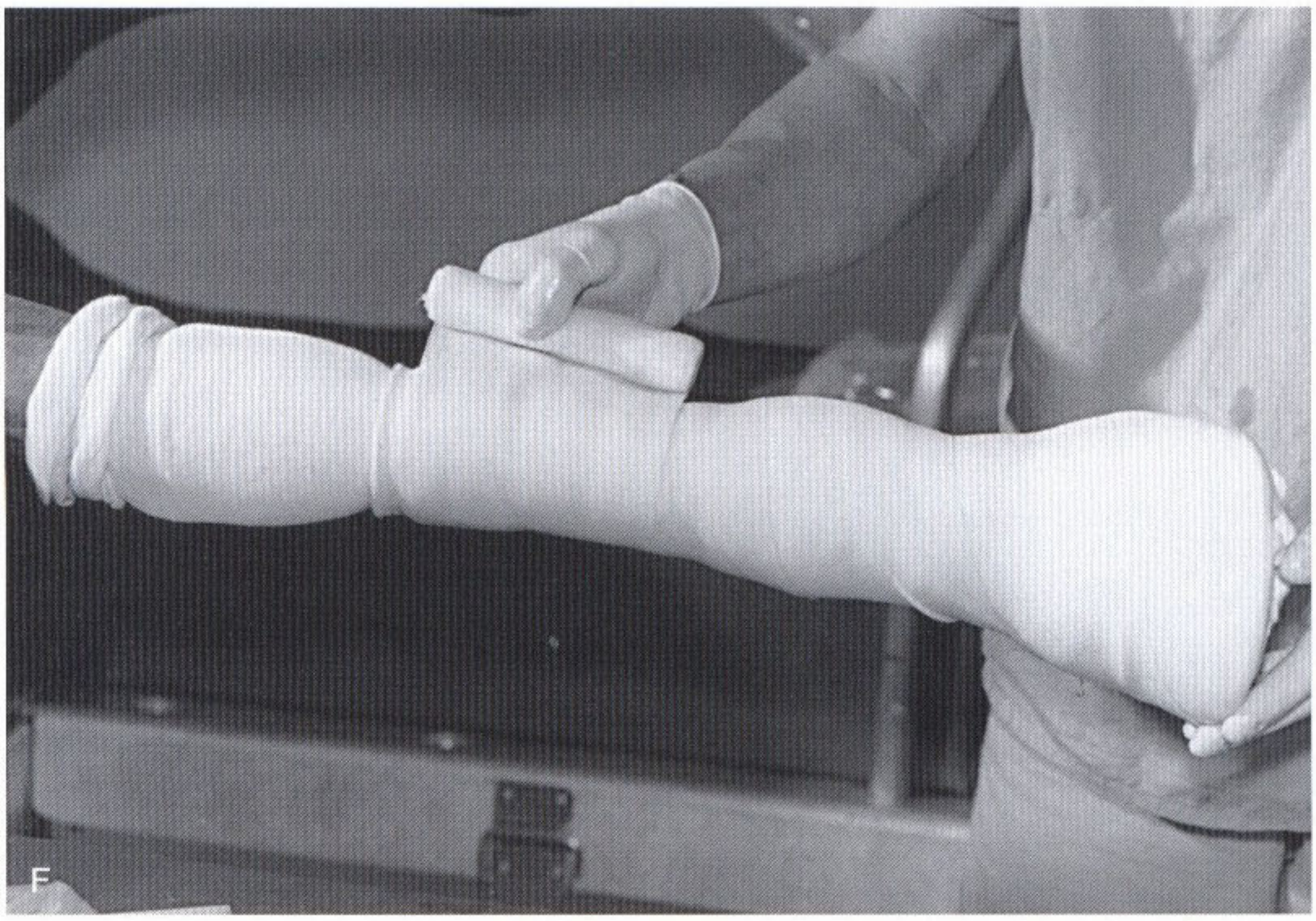
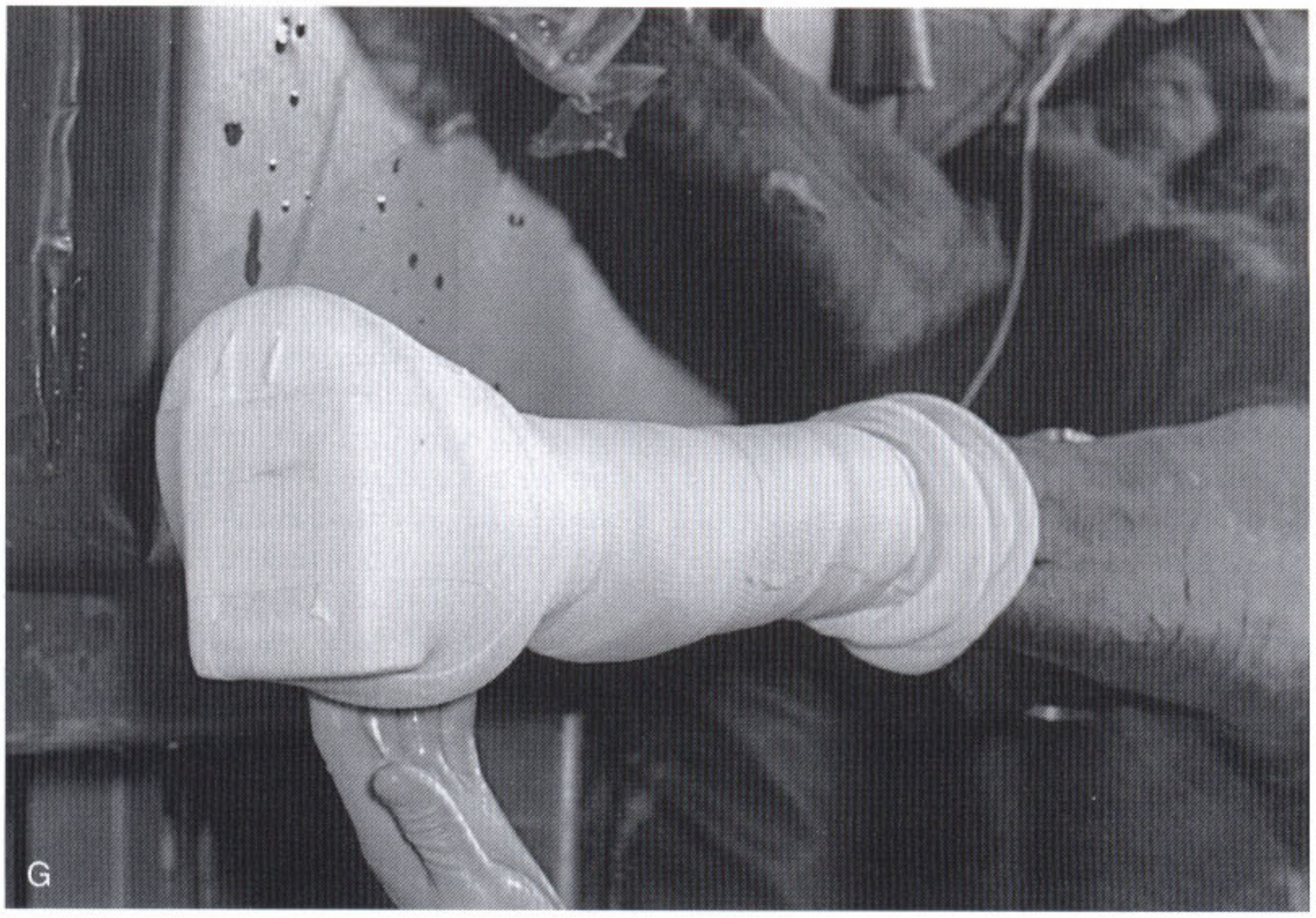


Figure 64–1. *Continued*

F, Fiberglass casting tape is applied with figure-of-eight reinforcement of the fetlock and pastern regions.



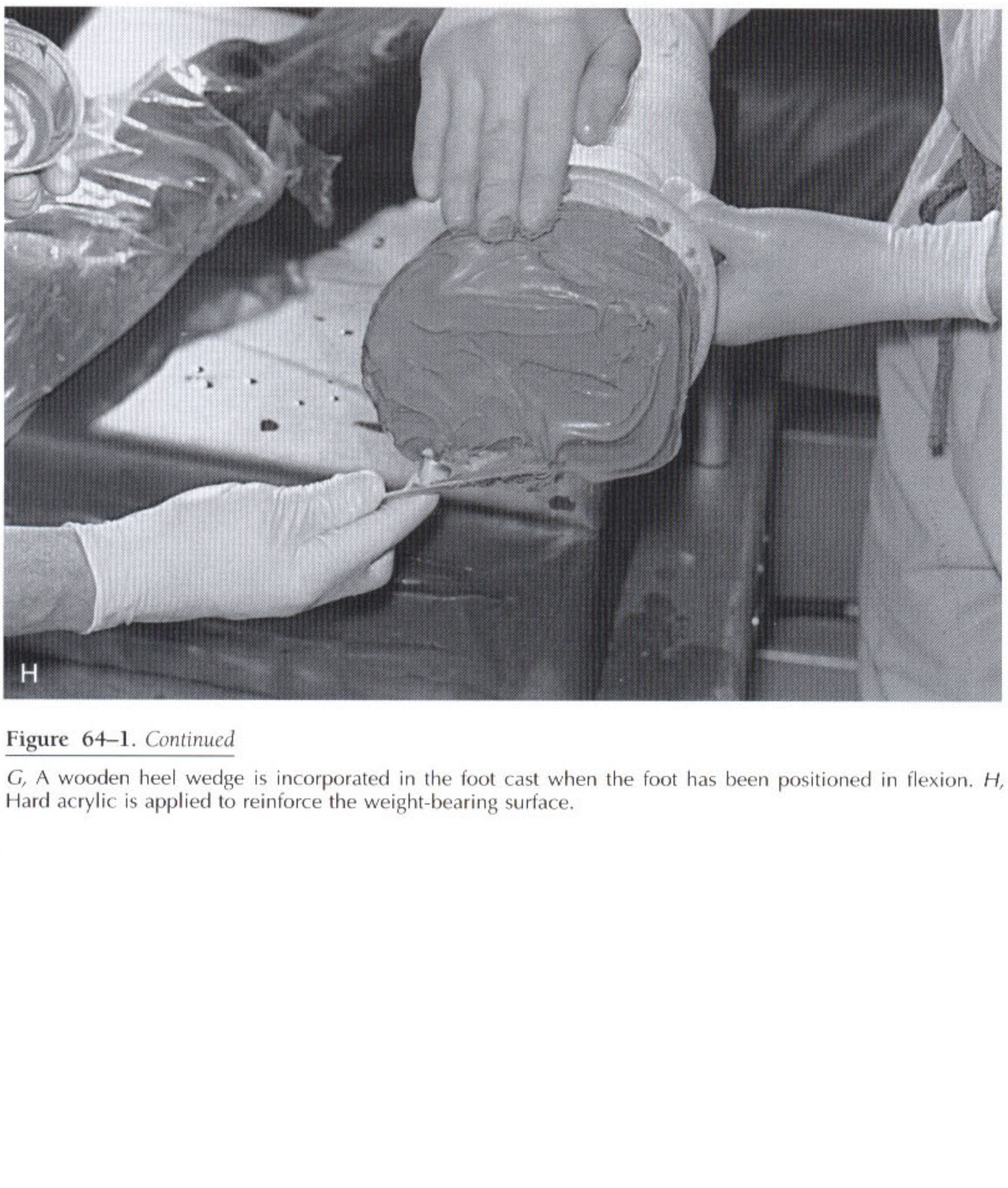


Figure 64–1. *Continued*

G, A wooden heel wedge is incorporated in the foot cast when the foot has been positioned in flexion. *H,* Hard acrylic is applied to reinforce the weight-bearing surface.

Half-Limb Cast with Transfixation

Transfixation casts, or so-called walking casts, are useful for providing increased axial stability over that provided by external coaptation alone.[4] Casts alone provide minimal axial stability; motion at a fracture site secondary to weight bearing can result in fragment displacement, collapse, prolonged pain, and delayed healing. Transfixation provides a method for transferring weight from the proximal skeleton to the cast, thus unloading the bones in the distal portion of the limb.[4, 5] Casts with transfixation are useful for severely comminuted fractures and similar injuries that cannot be treated with other forms of osteosynthesis.[4, 6] We have used them to unload and protect serious foot injuries when prolonged convalescence is anticipated. Immediate full weight bearing is possible, thus helping to protect the contralateral limb from biomechanical laminitis.

Three 1/4-inch-diameter shaft positive-profile centrally threaded pins[g] are inserted through the third metacarpal-metatarsal bone in horses weighing 200 kg or more. However, the use of two pins inserted through the distal diaphysis is satisfactory and preferred by some surgeons.[4] Smaller diameter pins are available for animals weighing less than 200 kg. To insert the pins, 1-cm release incisions are made down to the bone. A 6.2-mm drill bit[h] and tap with central threads[i] are used to drill and tap the bone in preparation for pin insertion (Figs. 64–2*A* and *B*). Release incisions are made for the drill, tap, and pins to exit the opposite side of the limb (Fig. 64–2*C*). Provided that the drill holes are tapped completely and irrigated, the threaded pins insert easily. It may be necessary to clean the flutes of both the drill and the tap of bone chips, particularly when machining bone that is as dense as the metacarpus, for the pins to be inserted without undue force. The pins should diverge as much as 30° in a coronal plane to avoid stress concentration and the possibility of secondary longitudinal oblique fractures when the pins are inserted in parallel.[7] With all three pins in position, the release incisions are covered with antibacterial-impregnated sterile dressing material, and the stockinette is rolled into position for casting (Fig. 64–2*D*).

[g]No. 21140 large-animal transfixation/casting pin with central thread, IMEX Veterinary, Inc., Longview, TX.

[h]Orthopedic drill bit, 6.2 mm, IMEX Veterinary, Inc., Longview, TX.

[i]Tap with central threads for pin 21140, IMEX Veterinary, Inc., Longview, TX.

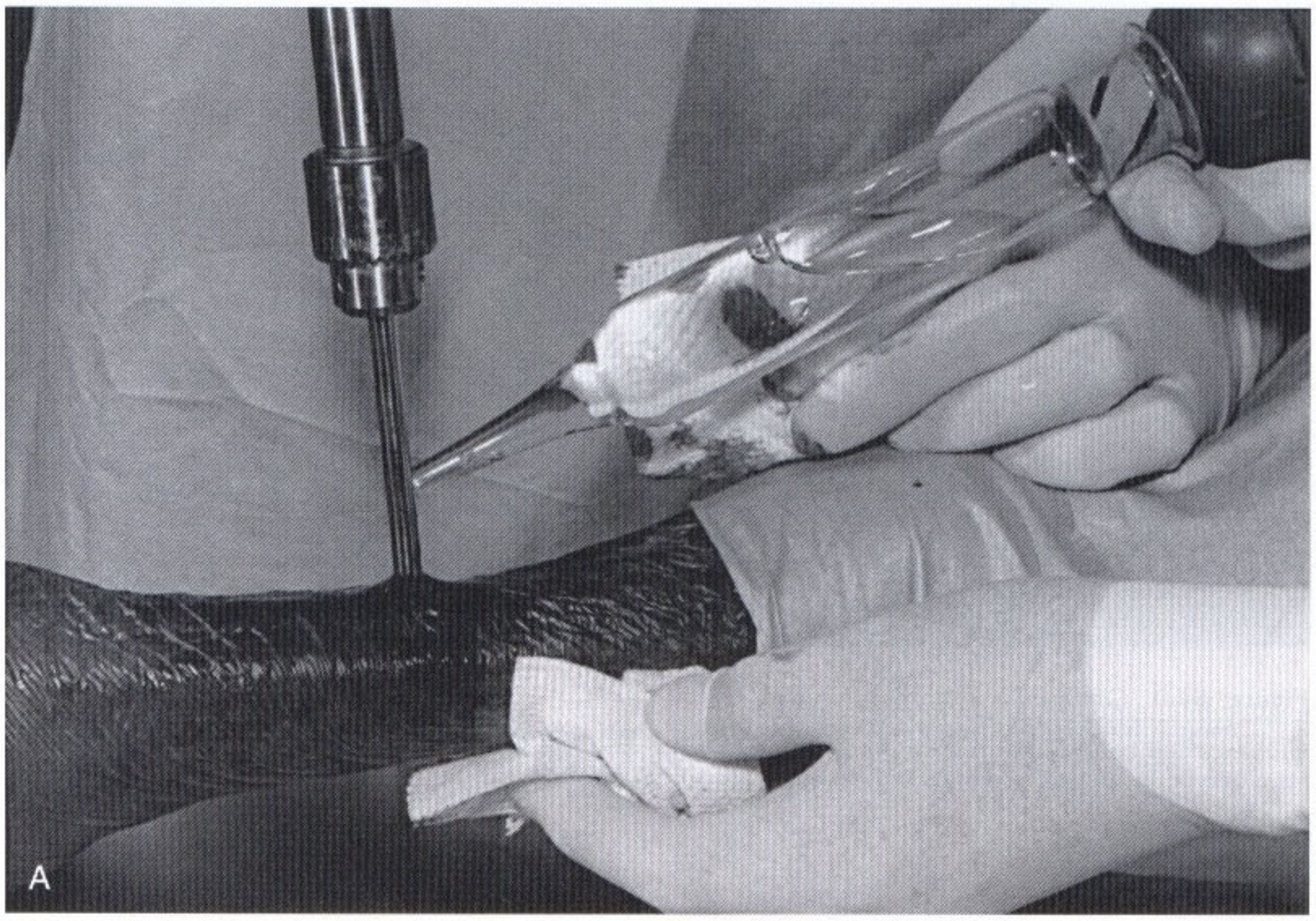


Figure 64–2.

Insertion of transfixtion pins in the metacarpus. *A,* Drilling the bone while irrigating the drill bit.

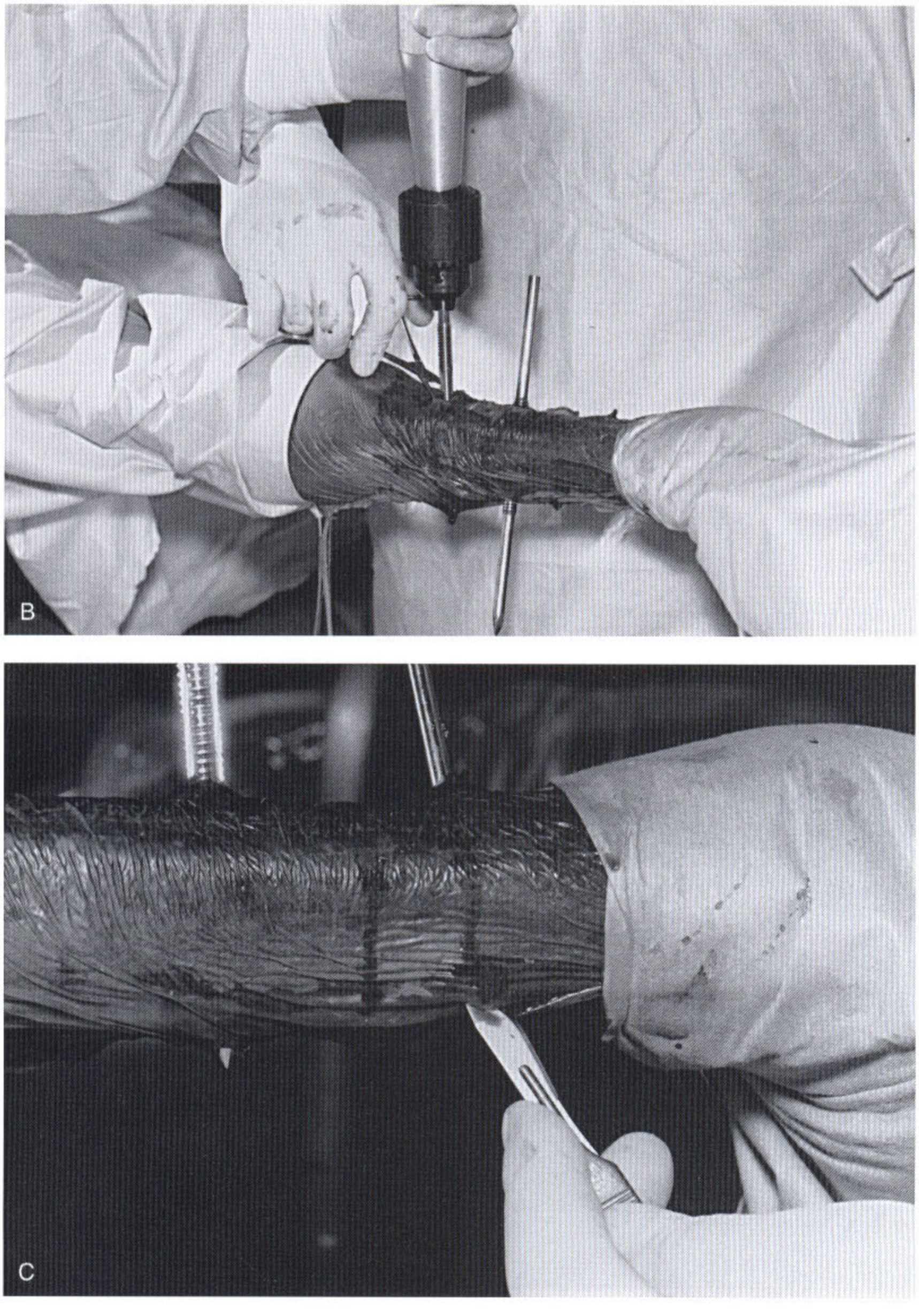


Figure 64–2. *Continued*

B, Tapping the drill hole. Note the use of a forceps to spread the soft tissues and skin. *C,* Release incisions are made for both the entrance and exit points for the drill, tap, and pins.

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The method of cast padding and fiberglass tape application is the same as that described for half-limb external coaptation, but the pins interfere with smooth application of the layers unless the tape is split with scissors to overlay the protruding pins (Fig. 64–2*E*). Several methods of incorporating the pins into the cast have been evaluated, and simple imbedding in the fiberglass is satisfactory.[8] After the cast has hardened, the ends of the pins are cut, leaving 6 to 8 mm of each pin protruding above the surface. The pins are further stabilized by incorporating the ends in a strip of hard acrylic, which extends distally and over the bottom of the fiberglass-encased foot, providing a walking bar effect (Fig. 64–2*F*). Transfixation pins remain tight for 4 to 8 weeks, eventually loosening because of infection or lysis at the bone–pin interface. When pins loosen, they should be removed and new pins inserted in healthy bone if continued transfixation is required.

Transfixation pins can be inserted in the radius or tibia for injuries of the metacarpus-metatarsus, carpus, and hock. Insertion of the pins in the radius or tibia requires the application of a full-limb cast.

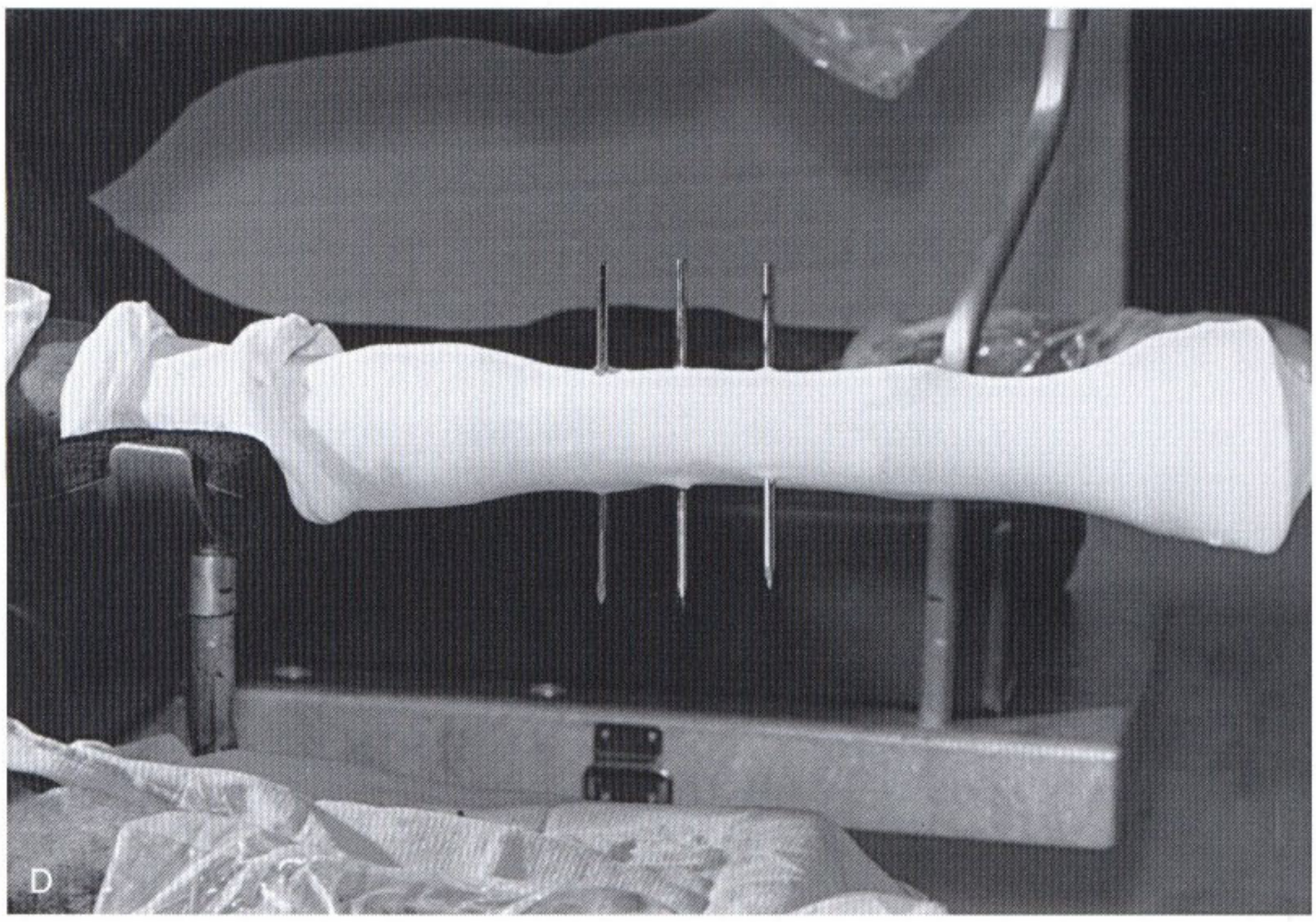
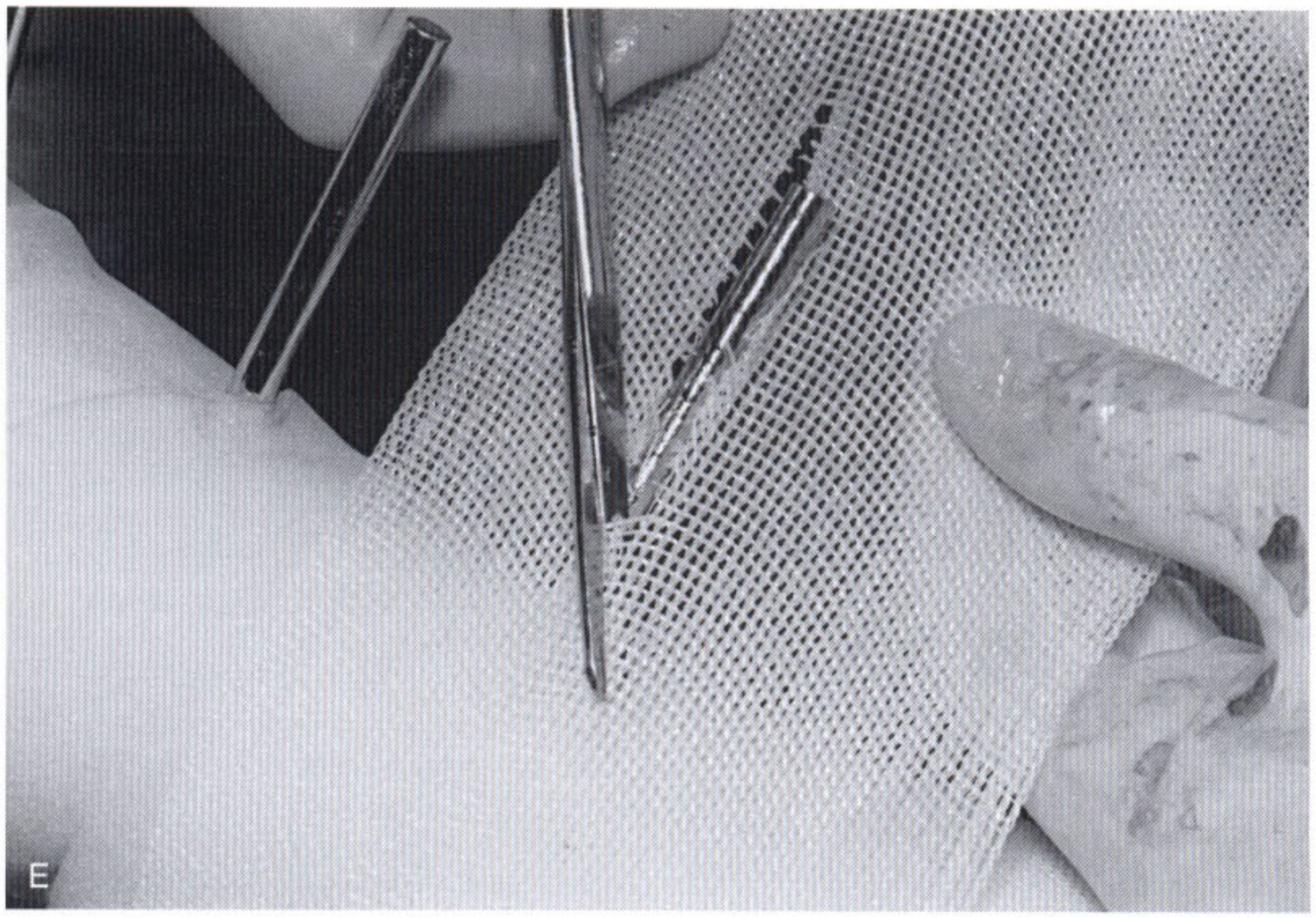


Figure 64–2. *Continued*

D, The pins diverge up to 30° to avoid stress concentration within the bone. With all three pins in position, the release incisions are covered with sterile dressing and the stockinette is rolled into position.



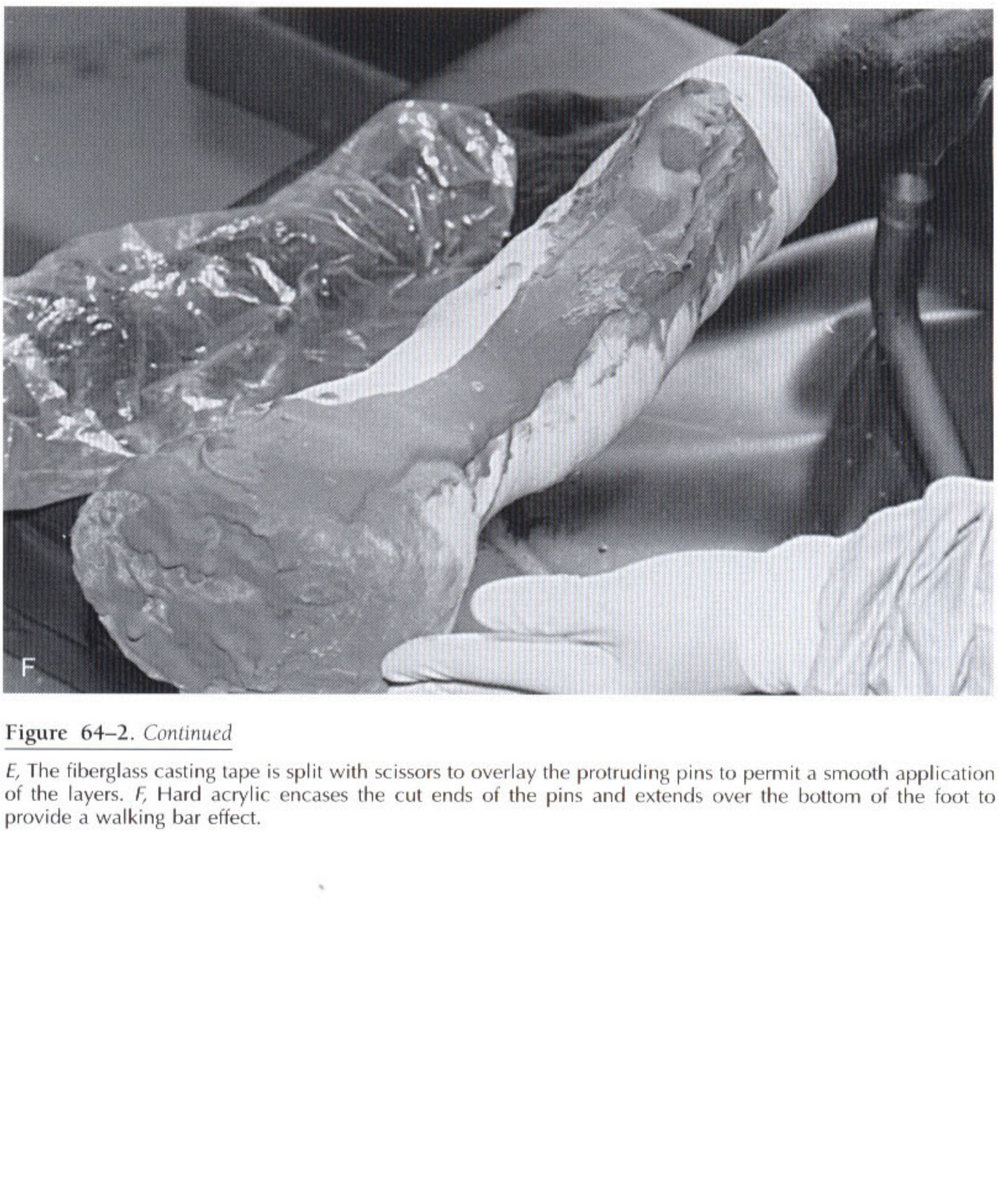


Figure 64–2. *Continued*

E, The fiberglass casting tape is split with scissors to overlay the protruding pins to permit a smooth application of the layers. *F,* Hard acrylic encases the cut ends of the pins and extends over the bottom of the foot to provide a walking bar effect.

Full-Limb Cast

Full-limb casts are useful for managing severely comminuted proximal and middle phalangeal fractures and proximal metacarpal-metatarsal, carpal-tarsal, or distal radial-tibial injuries in horses. The more proximal injuries benefit from transfixation. Full-limb casts must extend to the elbow or stifle and not end on the diaphysis of either the radius or tibia. The posture of the limb within the cast should accommodate natural standing and ambulation. For the forelimb, this is a semiflat-footed position with the carpus slightly flexed. Flexion of the carpus helps to reduce the axial forces within the cast. For the hind limb, relaxation of the digital flexors with the interphalangeal joints slightly flexed creates the most comfortable posture for the patient. Full-limb casts are rarely applied to the standing, sedated horse.

With the horse anesthetized and the limb properly positioned, stockinette is rolled from the foot to above the olecranon or patella. The coronary band is padded as described for the half-limb cast. A 3-inch-wide band of 1/4-inch orthopedic felt is applied at the proximal extent of the radius or tibia (Fig. 64–3*A*). The accessory carpal bone or tuber calcis is protected with an orthopedic felt pad, with a cutout contoured to the bony prominence (Fig. 64–3*B*). Two rolls of support foam are used for a full-limb cast, again starting from proximal to distal and creating a two-layer thickness with overlapping spirals. Full-limb casts on adult horses require 8 to 10 rolls of 4-inch fiberglass tape. Five-inch-wide fiberglass is useful for very large horses, and, because of the angulation, accordion-folded longitudinal splints of fiberglass can be used in the hind limb. When full-limb casts do break, this usually occurs at the level of the carpus or tarsus. Figure-of-eight wrapping of these areas provides additional strength. The foot is incorporated in fiberglass, and the weight-bearing surface is reinforced with hard acrylic, as described for half-limb casts.

Postoperative Management

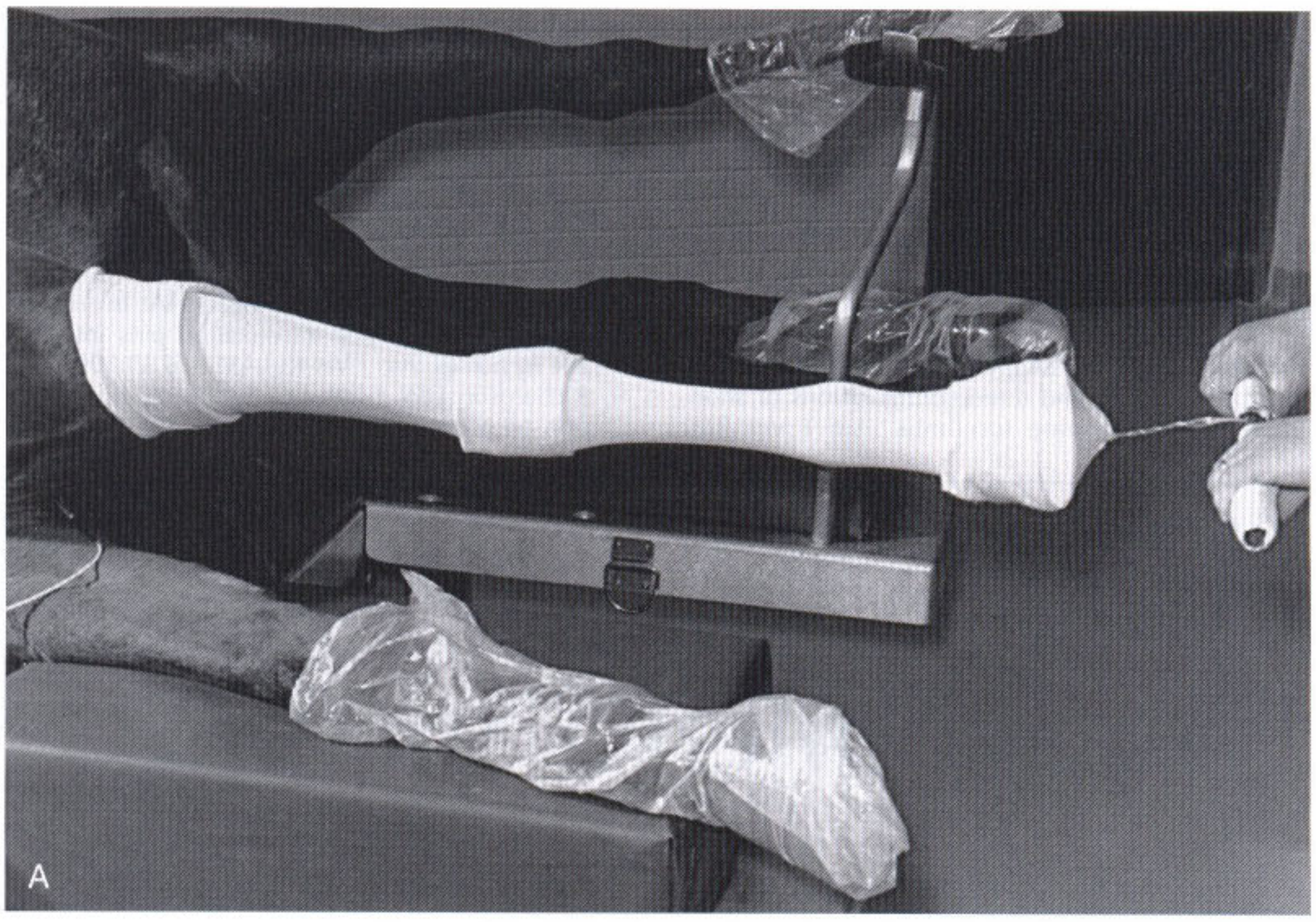
Horses wearing casts must be confined to a stall. Because fiberglass is semipermeable, the bedding must be kept dry. Straw is the preferred bedding, providing suitable footing and being sufficiently absorbent. The horse must be examined daily and assisted with locomotion as needed.[2] Broken casts must be removed or replaced immediately. The occasional horse may get down on the affected side, becoming stall-cast and unable to regain its footing. Hindlimb casts cause more problems in this regard than forelimb casts. The horse may need assistance in standing up for the first several days.

Support of the contralateral sole is important to reduce the threat of biomechanical laminitis. We use frog support pads[j] taped to the foot. Tendon and ligament strain occurs in all horses wearing casts, even those that spend time lying down. The contralateral limb is support-bandaged at all times. Horses that tend to experience edema in their limbs when confined benefit from support wraps on all three limbs. Well-fitting casts can be worn for up to 3 weeks in foals and up to 6 weeks in juvenile and adult horses without problems. Casts that are used to protect a wound repair can be removed in 2 to 3 weeks, after the soft tissues have had sufficient time to heal. Casts used to support severed tendons or fracture repair must be continued until clinical healing has advanced to the point at which external coaptation is no longer required. In such circumstances, casts are changed every 3 to 5 weeks or more frequently if indicated. Casts are removed by using an oscillating saw.[k]

The complications associated with fiberglass casting include pressure sores, osteopenia, joint stiffness, tendon and ligamentous laxity, and articular cartilage atrophy. The severity of these complications is directly proportional to the total length of casting and, to a lesser extent, the nature of the primary injury. Although reversible, they impact the length of convalescence after external coaptation has been removed. Because fiberglass is porous, palpable heat associated with the inflammation caused by a pressure sore can be difficult to detect on the surface. A change in the horse's willingness to use the casted limb may be the most important clue that problems exist. If the foot wears through the bottom of the cast or if the proximal rim of the cast, just distal to the carpus or tarsus, is ill-fitting, rubbing sores will develop.

Articular cartilage depends on joint motion for proper nutrition. Casting interferes with joint motion, and the articular cartilage atrophy after prolonged casting, past 30 days, may be irreversible. However, the changes in articular cartilage after simple cast immobilization for 30 days or less are minor and probably of little consequence.[9] Prolonged casting can result in some disuse muscle atrophy, particularly with full-limb casts. If the primary injury is associated with prolonged pain or debility, some suppression of appetite with weight loss can be expected. All of these complications and changes must be accepted as tradeoff risks in light of the widespread clinical value of external coaptation in equine surgery.

[j]Lily pads, Farrier Products, Shelbyville, KY.
[k]Stryker cast cutter, Stryker Instruments, Kalamazoo, MI.



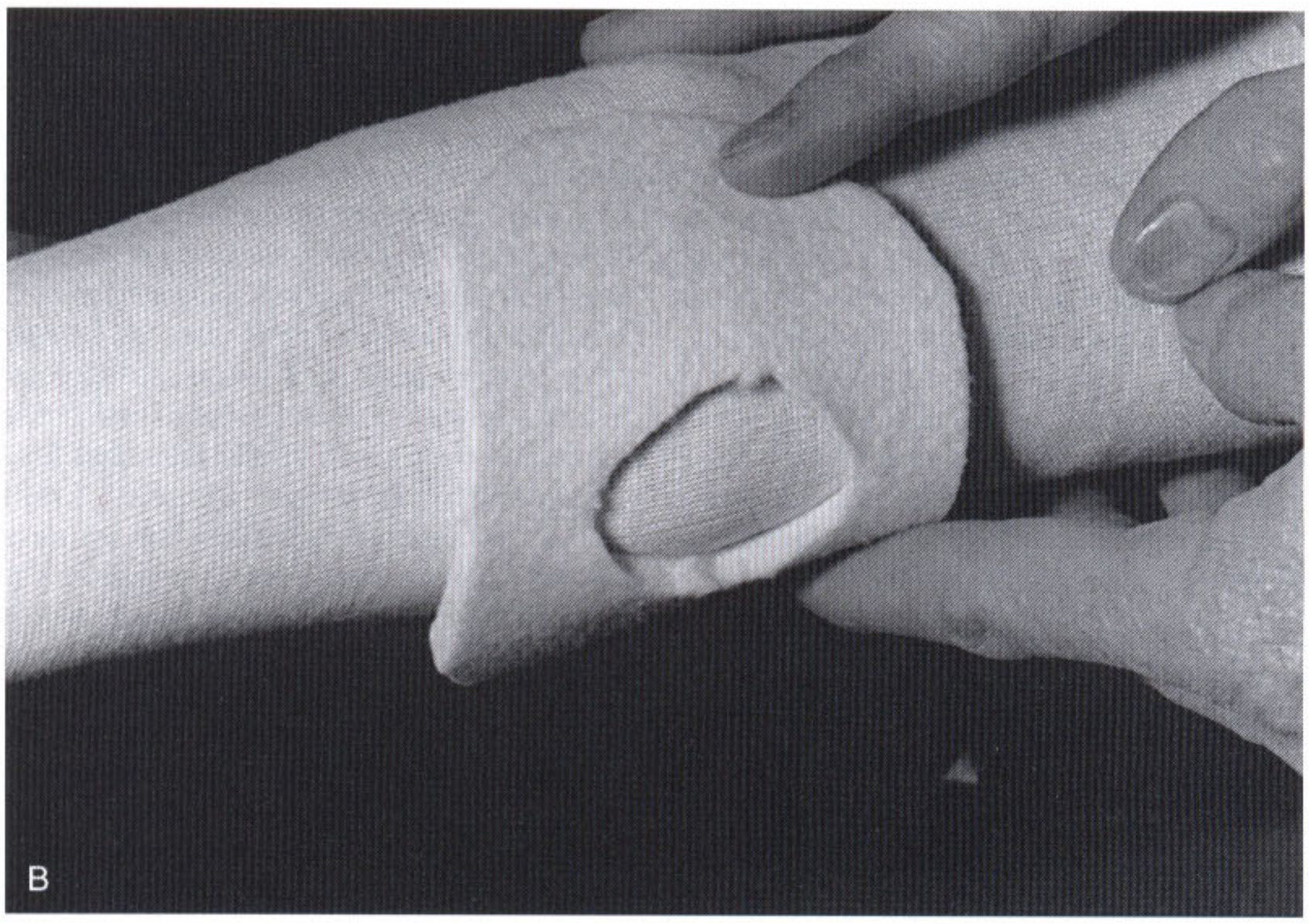


Figure 64–3.

Padding in preparation for a full-limb cast of the forelimb. *A,* A 3-inch-wide band of ¼-inch orthopedic felt is applied over two layers of stockinette just below the elbows. *B,* The accessory carpal bone is protected with a felt pad with a cutout. The remainder of the padding and cast application are the same as is illustrated for the half-limb cast (see Fig. 64–1).

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Musculoskeletal System Surgery

chapter 65

Palmar Digital Neurectomy

A number of conditions of the equine foot that cause pain in the heel region (e.g., navicular syndrome, wing fractures of the third phalanx) can be managed by palmar digital neurectomy. This procedure can extend the useful athletic life of a horse. Neurectomy was performed more frequently 20 or 30 years ago than it is today. Now, palmar digital neurectomy is often viewed as a treatment of last resort for navicular syndrome. There are several reasons for this. First, our understanding of the pathophysiology of equine foot diseases that cause heel soreness and lameness is much improved and has led to successful treatment alternatives other than surgical denervation.[1, 2] Second, society has developed a growing concern for the welfare of the animal; our clients who have horses as companion animals are accepting alternatives to surgery with increasing frequency. Third, in spite of the many varied techniques that have been evaluated, palmar digital neurectomy is associated with a number of shortcomings and several significant complications that reduce the postsurgical effectiveness of the procedure over time.[2, 3]

Proper diagnostic technique and patient evaluation must precede the selection and use of palmar digital neurectomy as the treatment of heel pain. Regional anesthesia of the palmar digital nerves at the surgical site of neurectomy should alleviate at least 90% or more of the lameness. The owner or trainer and the veterinarian should agree that the improvement in gait after regional anesthesia is in keeping with the level of performance and comfort for the horse that is desired. If possible, the palmar digital anesthesia should be evaluated in a performance setting, such as at the racetrack or during a competitive event. Palmar digital neurectomy is contraindicated if palmar nerve anesthesia does not alleviate the lameness. Neurectomy at a more proximal location, at the fetlock or higher, is not recommended.

Although palmar digital neurectomy has been performed at the time of diagnostic anesthesia with successful results, it is preferable to wait for up to 3 weeks after the diagnostic anesthetic injections to perform the surgery. A separation in time between the tissue irritation associated with the anesthetic injection and the inflammation caused by surgery is believed to reduce the complications associated with neurectomy, particularly painful neuromas. The legal acceptability of palmar digital neurectomy in performance horses varies by state, by use, and by certain associations. The responsible individual must be certain that the horse will not be inadvertently disqualified by the surgery.

Anesthesia, Positioning, and Surgical Preparation

The occasional horse with a unilateral wing fracture of the third phalanx may need transection of a single nerve on the ipsilateral side, but most horses require transection of both the medial and lateral palmar digital nerves, and usually in both forefeet. Palmar digital neurectomy can be performed on the standing horse using chemical restraint and regional anesthesia. When done this way, the local anesthetic should be injected over the distal palmar-plantar nerves at the level of the fetlock, where the nerves are readily palpable on the abaxial surfaces of the proximal sesamoid bones. This removes the irritation caused by the local anesthetic from the incision site. Because atraumatic surgery, good hemostasis, the removal of small branches

of the palmar digital nerves, and the preclusion of infection are important in reducing complications, we prefer general anesthesia, even for the simple guillotine method of nerve transection. For positioning, one author (SBA) prefers lateral recumbency and the other (JFF) prefers dorsal recumbency with the forelimbs extended. Lateral recumbency permits passive flexion of the fetlock at the time of nerve transection, which aids recoil of the proximal nerve stump out of the surgical field, but the horse must be rolled and repositioned during surgery for bilateral neurectomy. Dorsal recumbency provides a bloodless surgical field, precludes repositioning the horse, and puts the surgical sites at a convenient working height, but in this position the fetlocks cannot be flexed completely and proper draping of the feet can be difficult.

This surgery warrants routine aseptic technique. The limbs are clipped from the midmetacarpal region to the coronary band, and the palmar pastern regions are scrubbed. Impervious self-adhering drapes[a] are useful for shrouding the hoof capsule (see Chapter 3). No special instruments are required for the guillotine method of neurectomy. Perioperative antibiotics are not used routinely.

Surgery

A 3- to 4-cm-long incision of the skin and subcutaneous tissues is made along the lateral border of the deep digital flexor tendon and centered between the middle and lower thirds of the pastern region (Fig. 65–1*A*). The yellowish ligament of the ergot and white palmar digital nerve are identified just beneath the skin. It is important to use sharp dissection and to incise the subcutaneous tissue completely for the nerve to be readily apparent. We prefer to locate the incision directly over the palmar digital nerve and not disturb the ligament of the ergot as part of the dissection. The ligament of the ergot is avoided by making the incision palmar and distal to its subcutaneous course.

Up to 50% of horses have anatomic variations in nerve distribution, including small branches of the palmar digital nerve that follow the ligament of the ergot.[4] The unusual horse will have a palmar digital branch arising from the dorsal digital nerve; such cases are a problem for diagnosis and treatment.[4] Small branches should be identified and resected before the primary nerve is dissected free and exposed. Alternatively, 3 to 4 cm of the palmar digit nerve, including the proximal portion from which the branches arise, can be removed.

The palmar digital nerve is elevated from the surrounding fascia by a combination of blunt and sharp dissection. Once the nerve is positioned over the jaws of curved hemostats, the forceps is opened to strip away perineural fascia (Fig. 65–1*B*). Occasionally, Metzenbaum scissors are needed to incise the fascia and free a liberal length of the nerve. A small satellite artery usually accompanies the nerve and should be preserved (Fig. 65–1*C*). Severance of this artery can lead to postoperative hemorrhage and unnecessary scar formation. Separation of the palmar digital nerve from its small satellite artery by sharp dissection helps to free the nerve for 3 cm without tension. With the incision properly positioned, inadvertent dissection and exposure of the palmar digital artery are unlikely. The nerve is positively identified by observing the longitudinal fascicles or palpating them with a thumbnail with the nerve stretched over the hinge of the hemostats (see Fig. 65–1*C*). The stretched nerve is less elastic than the palmar digital artery; the nerve stays stretched and wrinkles when the tension is released, whereas the artery recoils to its wound bed.

The nerve is severed at the distal end of the incision using a new scalpel blade or a sterilized razor blade. Forceps are used to stretch the nerve, and, with the fetlock flexed, the proximal end is severed quickly and cleanly at the proximal commissure of the skin incision (Fig. 65–1*D*). This should provide for removal of at least 3 cm of nerve with recoil of the proximal stump away from the incision as an aid in the prevention of painful neuromas. The incision is closed in two layers. The subcutaneous tissues and dermis are sutured with a simple continuous pattern using a size 3–0 delayed-absorbable material.[b] This layer should approximate the skin without exposure of the dermis. Interrupted sutures of size 2–0 polypropylene[c] that split the skin thickness are placed in the epidermis.

Postoperative Management

A sterile pressure bandage is maintained on the operated limb for at least 2 weeks. Phenylbutazone, 2.2 mg/kg per os b.i.d., is administered for 2 to 3 days after surgery to help minimize postoperative inflammation. Skin sutures are removed by the 10th day, and the horse is not returned to athletic performance for at least 4 weeks, preferably 6 weeks. When aseptic technique and careful surgical dissection have been used, incisional complications, such as infection, are rare.

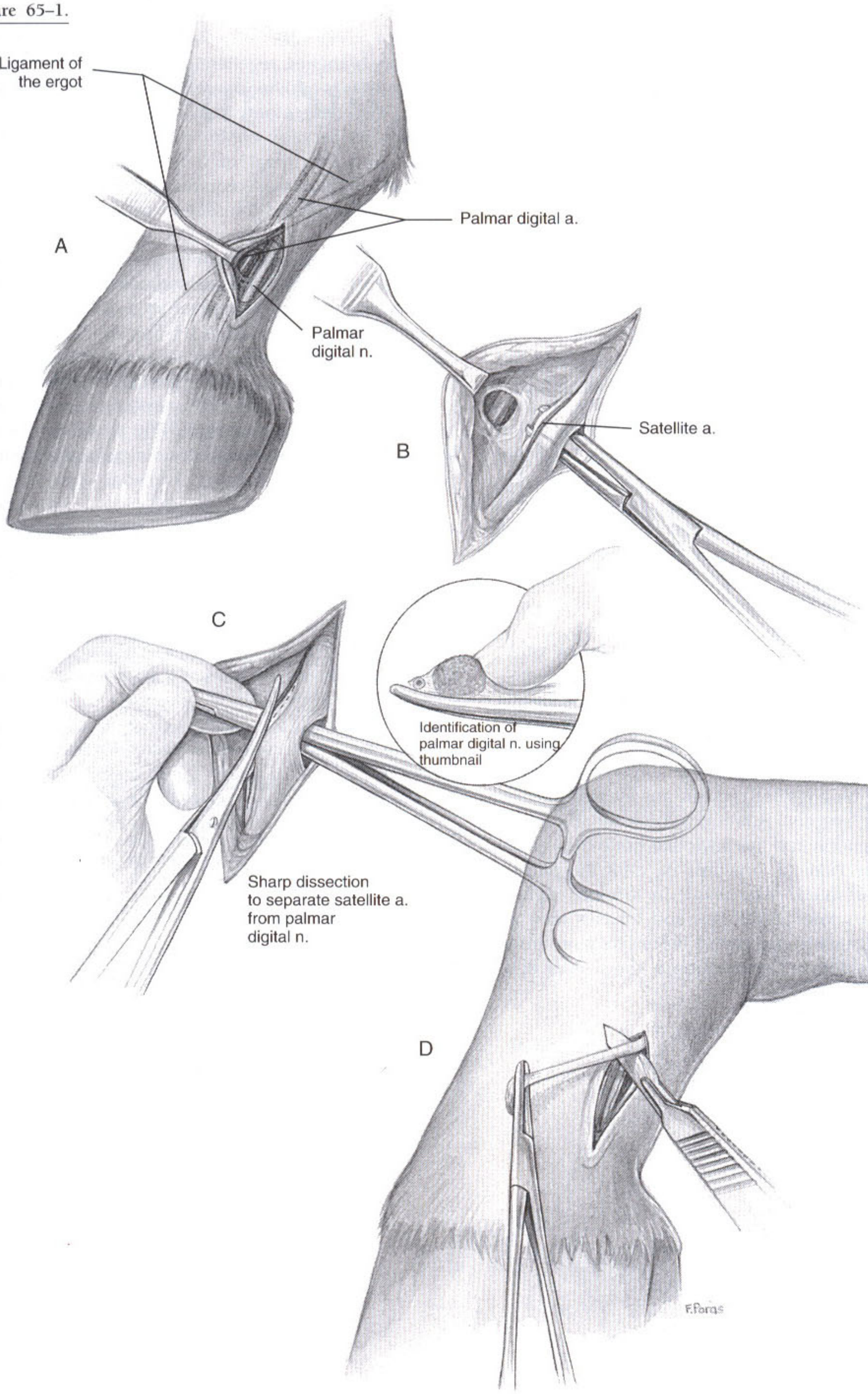
The formation of non-neoplastic enlargements at the ends of transected nerves is normal. Painful neuromas are believed to occur when regenerating nerve fibers are exposed and uncovered by epineurium and reinnervate surrounding tissues. Many techniques, all aimed at minimizing neuroma formation and preventing regrowth of the severed nerves, have been evaluated in recent years. Stainless steel and Silastic caps

[a]Ioban 2, Animal Care Products, 3M Health Care, St. Paul, MN.

[b]PDS II, Ethicon, Inc., Somerville, NJ.

[c]Prolene, Ethicon, Inc., Somerville, NJ.

Figure 65–1.


Ligament of the ergot
Palmar digital a.
Palmar digital n.
A
B
Satellite a.
C
Identification of palmar digital n. using thumbnail
Sharp dissection to separate satellite a. from palmar digital n.
D
F.Forms

have been placed over nerve stumps in an unsuccessful attempt to contain nerve fiber regeneration. We, and others, have used epineural capping for years, but the procedure is more tedious than simple guillotine neurectomy and not completely free of neuroma formation.[4, 5] Electrocoagulation of the nerve stump and application or injection of radiation, corticosteroids, sodium hyaluronate, tissue adhesives, and several cytotoxic drugs to control neuroma formation have been done with equivocal or negative results. A limited study of the use of the carbon dioxide laser to perform neurectomy is encouraging, but this requires expensive equipment that is not readily available.[6] The proximal nerve end can be tunneled into bone as a way of controlling neuroma formation, but the procedure is more involved, postoperative neuritis develops in a high percentage of cases, and the convalescent time is prolonged.[7] Although there have been improvements, there is no single method that is simple, effective, and free from complications. The consequences of painful neuromas can be minimized by limiting the irritation and scar tissue formation at the incision site, stretching the nerve and transecting it with a sharp guillotine cut, maintaining a postoperative pressure bandage, and waiting at least 6 weeks before returning the horse to a performance status.

In addition to neuromas, there are several other reasons for an unsuccessful clinical response after palmar digital neurectomy. Misinterpretation of the results of neurectomy will occur when diagnostic nerve blocks desensitized a larger area than that innervated by the palmar digital nerves removed by surgery. Accessory branches may be anesthetized but not located and removed during surgery. Adhesions between the deep digital flexor tendon and the navicular bone may cause a persistent mechanical lameness or, after the painful lameness is relieved, may result in tendon rupture months or years later. Abscesses and injuries may go undetected because of the partial desensitization of the foot after neurectomy. Regeneration of the palmar digital nerves with reinnervation of the heel can occur as early as 4 months after surgery. The treatment for missed accessory branches, regeneration of the nerves, or painful neuromas is another operation. Too much scar tissue after the first neurectomy and, certainly, the scar formation after reoperation contribute to a relative ischemia of foot and the threat of a hoof capsule slough.[4, 8] Removal of neuromas requires a more proximal approach and threatens transection of the dorsal palmar nerve branch.

On the basis of one long-term follow-up study, 34% of operated horses sustained complications.[3] One year after palmar digital neurectomy, about 70% of the operated horses were sound.[2, 3] This drops to 60% by the second year after surgery. If these limitations are kept in mind, palmar digital neurectomy will continue to have a place in the management of horses with intractable heel pain, particularly those horses for which athletic soundness is economically important.

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chapter 66

Navicular Suspensory Desmotomy

Transection of the suspensory ligaments of the navicular bone has been described for the treatment of navicular disease.[1–3] This surgery is an alternative to palmar digital neurectomy and should be done in addition to balancing the feet and applying corrective shoes. Surgery is usually performed biaxially in both forelimbs of horses with navicular disease.[3] If the surgery is successful, the horse will be sound and will not require the administration of analgesics or vasoactive drugs. The procedure appears to be safe and is relatively easy to perform.[3]

Proper selection of horses for navicular suspensory desmotomy is important for a successful outcome. Horses should have clinical and radiographic evidence of navicular disease with lameness that can be eliminated or reduced significantly with intra-articular anesthesia of the distal interphalangeal joint. Horses with lameness of less than 1 year's duration are more likely to improve after surgery.[3] Radiographic evidence of flexor cortical defects, proximal border enthesopathy, medullary sclerosis of the navicular bone, and mineralization of the deep digital flexor tendon all adversely affect the prognosis.[2] Desmotomy of the navicular suspensory ligaments is successful in 66 to 71% of horses 6 months after surgery, but this decreases to approximately 40% 3 years after surgery.[2, 3]

Anesthesia, Positioning, and Surgical Preparation

Phenylbutazone or another suitable nonsteroidal anti-inflammatory drug is given preoperatively. After induction of general anesthesia, the horse is positioned in dorsal recumbency. Hair is removed from the coronary band to just above the fetlock around the entire circumference of the limb. The bottoms of the feet should be covered with surgical gloves secured with tape. An Esmarch bandage[a] is applied as a tourniquet and is secured above the fetlock. After routine aseptic surgical preparation of the incision sites, which should include some of the proximal hoof wall, the limbs are draped and flexed so that the feet rest on the ventral thorax. This position allows access to all four surgical sites.

[a]Esmarch bandage, American Hospital Company, McGaw Park, IL.

Surgery

Transection of the suspensory ligaments is performed as described by Wright.[2] A 4-cm vertical skin incision is made midway between the common digital extensor tendon and the distal eminence of the proximal phalanx. The incision extends proximally from 0.5 cm above the coronary band to the level of the eminence on the proximal phalanx. The incision continues deeper through the subcutaneous tissue to the cartilage of the distal phalanx and to the navicular suspensory ligament (Fig. 66–1*A*). The surgeon should avoid severing the veins that form the coronary plexus superficial to the cartilage.

The navicular suspensory ligament runs in a dorsoproximal-distopalmar direction from its origin on the distal aspect of the proximal phalanx and passes deep to the cartilage of the distal phalanx. Dissection axial (deep) to the cartilage allows identification of the dorsal margin of the navicular suspensory ligament. A small, curved hemostat is passed in a dorsopalmar direction under the navicular suspensory ligament as it passes axial to the cartilage of the distal phalanx, and a no. 11 scalpel blade is used to transect the ligament (Fig. 66–1*B*). The subcutaneous tissues are closed with a simple continuous suture pattern using size 2–0 polydioxanone[b] suture material, and the skin is closed with size 1–0 polypropylene[c] in a simple interrupted or vertical mattress pattern. The opposite navicular suspensory ligament in the same limb and the ligaments in the opposite limb are transected in the same fashion.

[b]PDS II, Ethicon, Inc., Somerville, NJ.
[c]Prolene, Ethicon, Inc., Somerville, NJ.

Postoperative Management

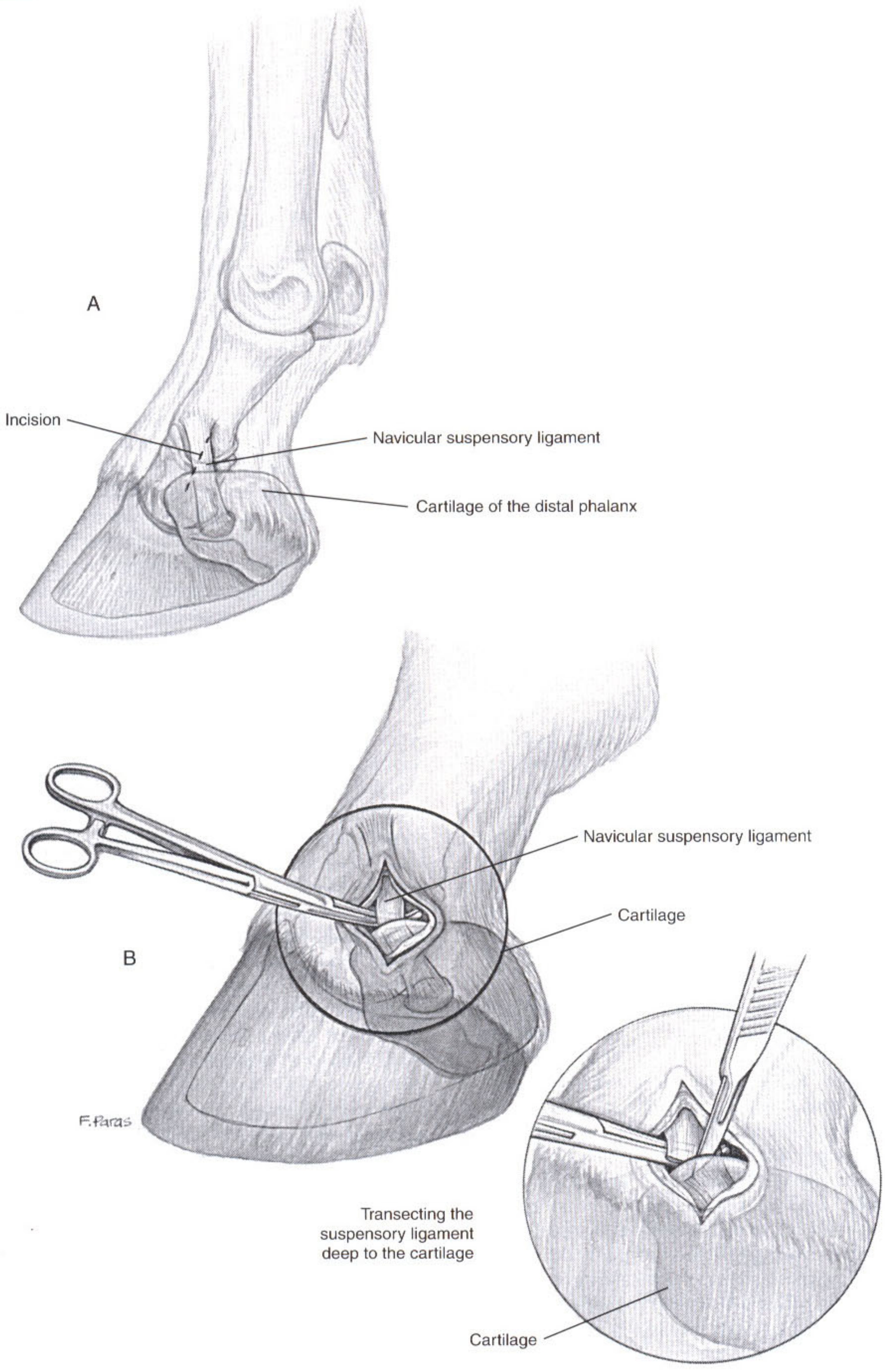
Sterile wound pads are placed over the incisions, and the limbs are bandaged. Bandages are maintained for 10 to 12 days. The skin sutures are removed in 7 to 10 days. Hand-walking exercise can begin the day after surgery and is continued for 3 weeks. Thereafter, a gradually increasing exercise program is implemented with the goal of achieving full work levels by 3 months after surgery.[2] The feet should be balanced and corrective shoes suitable for horses with navicular disease applied before implementing the exercise program.

Complications are infrequent but include wound dehiscence, infection, local swelling, and objectionable postoperative scarring.[2] Some horses improve but do not become completely sound.[3] These horses may be further helped with systemic analgesics or medication instilled in the distal interphalangeal joint.

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Figure 66–1.


A
Incision
Navicular suspensory ligament
Cartilage of the distal phalanx
B
Navicular suspensory ligament
Cartilage
F. Paras
Transecting the suspensory ligament deep to the cartilage
Cartilage

chapter 67

Navicular Bursotomy

Penetrating injuries of the equine foot are common. They can be overlooked for several days while the resultant inflammation and infection lead to a non-weight-bearing lameness. Puncture wounds, by definition, involve a more serious injury to deeper structures than what is apparent on the surface. This is particularly true for the ground surface of the foot, where joint, tendon, bursal, and bony structures are immediately beneath the sole and frog. The concavity of the sole and the sulci of the frog tend to direct sharp objects toward the navicular region. Such penetrations may lead to septic deep digital tenosynovitis, septic navicular bursitis, osteomyelitis of the navicular bone, and septic arthritis of the distal interphalangeal joint when the distal sesamoid ligament of the navicular bone (impar ligament) has been penetrated. When definitive treatment is delayed, the extension of inflammation and infection may result in pathologic fracture of the navicular bone and rupture of the deep digital flexor tendon, which leads to subluxation of the distal interphalangeal joint. These complications can be life threatening.

Deep puncture wounds of the navicular region of the foot that enter synovial structures are refractory to medical treatment alone and refractory to surgical treatment if it is delayed. Equine surgeons must take an aggressive approach in the diagnosis and management of severely lame horses when a foot puncture is suspected. Often the history is helpful, but horses that are unobserved can "step off" a nail or foreign body and have no obvious evidence of the puncture. Because of the high moisture content and semirigid nature of the frog and sole, the horn substance tends to close, sealing the puncture site from easy detection.[1] The shoe must be removed and the foot trimmed closely to identify the puncture site. This can be tedious, hard work, particularly when the hoof capsule is dry and overgrown and the foot is painful. However, aggressive hoof trimming is the only way to be certain about the presence and location of a puncture site.

The depth and direction of the penetration must be determined as a part of the physical examination. The use of a flexible blunt probe to sound the puncture tract and a complete radiographic evaluation of the foot are essential. After a surgical scrub of the site and with the foot anesthetized by regional nerve blocks, a sterile probe can be introduced into the tract. Misdirection of the probe with damage to unaffected structures must be avoided. Radiographs can be made with the probe in place, or contrast medium can be injected in the tract to create a contrast fistulogram. Lateromedial, dorsoproximal-palmarodistal oblique (upright pedal), and 60° palmarodorsal-proximodistal oblique (caudal tangential) projections are essential.[2] Dorsolateral-palmaromedial oblique and dorsomedial-palmarolateral oblique projections may be necessary to assess fully the third phalanx as well as the navicular bone and distal interphalangeal joint.[2] Contrast fistulograms may reveal the involvement of the navicular bursa, distal interphalangeal joint, or deep digital flexor tendon sheath, but penetration of these synovial structures will not be determined with contrast fistulography in up to 50% of the cases.[3]

Surgical exploration is the most reliable way to determine the extent of puncture wounds. The joint capsule, navicular bursa, and tendon sheath are in close approximation in the navicular region (Fig. 67–1). All three structures are prone to injury from a puncture wound or extension of infection from one structure to another. Once the presence of a puncture wound is established and involvement of the navicular bursa or other closed cavity has been proven or suspected, surgical debridement and drainage should be performed on an urgent basis, preferably within the first 3 days after injury.[4, 5] The intent of surgery is to convert a contaminated wound to a clean-contaminated status, to limit or avoid closed-cavity infection of synovial structures, to promote drainage, and to establish a wound environment for optimal healing.

Anesthesia, Positioning, and Surgical Preparation

General anesthesia is required for navicular bursotomy. Because of the high sensory innervation of the affected tissues, regional nerve blocks of the foot at the proximal sesamoid level reduce the required depth of general anesthesia. The horse is positioned in lateral recumbency with the affected foot up. The limb is raised slightly to provide access to the solar surface and frog and as an aid in controlling hemorrhage. All hair is clipped from the limb from the coronary band to just below the carpus or tarsus. The hoof is trimmed short, with all dirty or discolored recesses removed. The frog and bars are thinned and the sulci of the frog trimmed so that all dirt in the crevices is removed. The hoof wall

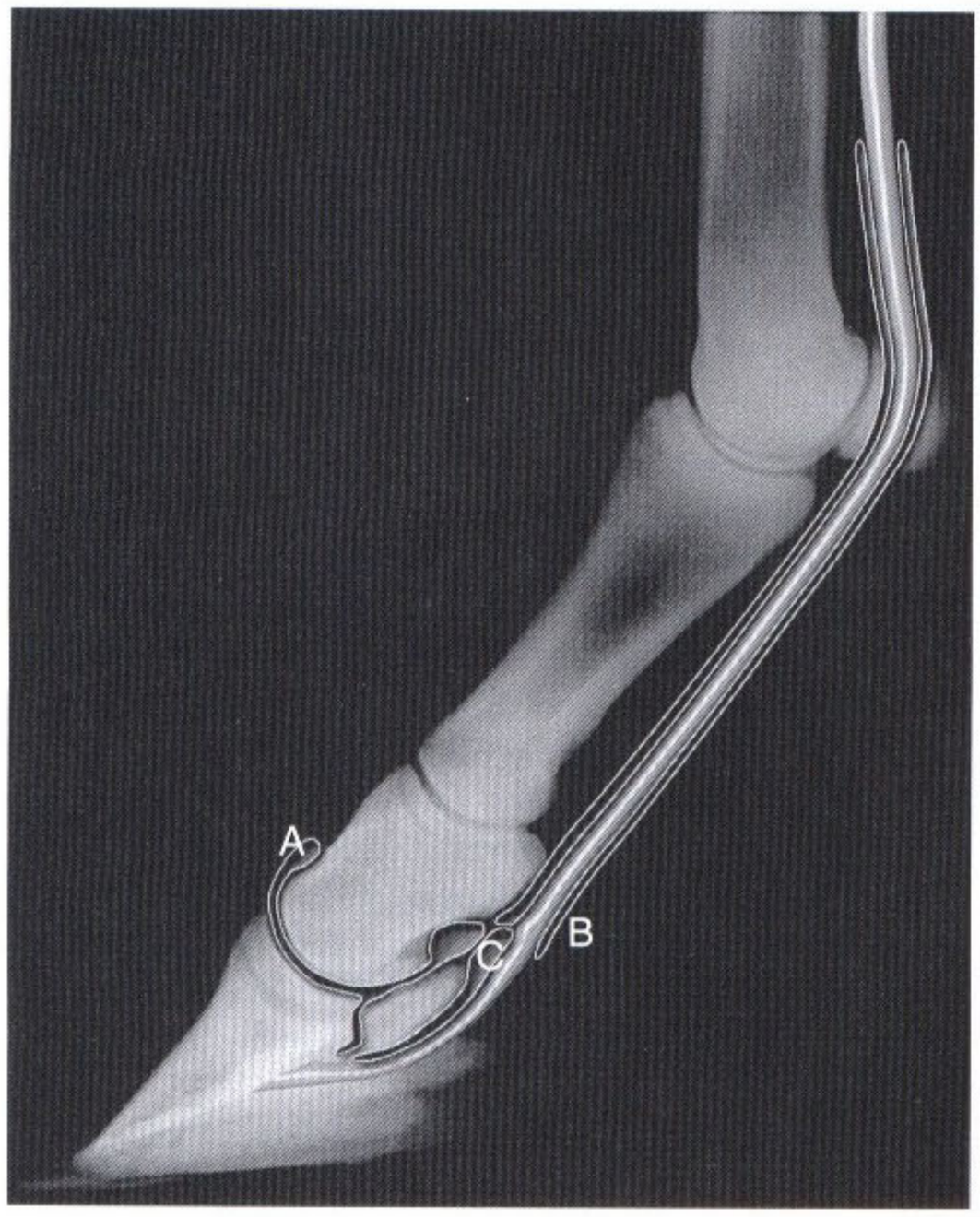


Figure 67–1.

Superimposition of the synovial cavities on the bony structures of the distal limb. Note the proximity of the distal interphalangeal joint capsule (A) and the deep digital flexor tendon sheath (B) to the navicular bursa (C). All three synovial cavities are vulnerable to direct injury or to the intercompartmental extension of inflammation and infection.

is rasped to remove the periople and surface irregularities. Close trimming and rasping are essential first steps in reducing the bacterial contamination during surgery and early convalescence.

The foot and entire circumference of the limb are routinely scrubbed for aseptic surgery from the sole surface to the midcannon region. The hoof capsule itself is scrubbed with a sterile hand brush. The surgeon must be prepared to surgically invade all foot structures up to and including the deep digital flexor tendon sheath above the fetlock. A sterile Esmarch tourniquet is applied and then unwound from the hoof capsule to just below the carpus or tarsus, and a final surgical scrub is applied. The exsanguination is maintained during surgery by the top portion of the Esmarch bandage or with a pneumatic tourniquet[a] (see Chapter 4). We use aseptic technique, including draping of the operative field and full surgical attire. Perioperative antibiotics that provide broad-spectrum coverage are indicated. We regularly use penicillin G potassium,[b] 22,000 U/kg, and gentamicin sulfate,[c] 6.6 mg/kg, given as intravenous boluses just before induction of anesthesia.

[a]Pneumatic tourniquet, Walter Kidde, Mebane, NC.

[b]Penicillin G potassium, Bristol-Myers Squibb Co., Princeton, NJ.

Surgery

Before the puncture wound or the navicular bursa itself is explored, standard arthrocentesis of the distal interphalangeal joint via the dorsal approach is performed.[1] Synovial fluid is collected for laboratory analysis and culture. The joint is pressurized with sterile polyionic solution and the puncture site observed for outflow as a means of determining joint involvement (Fig. 67–2*A*). If the deep digital flexor tendon sheath is distended, it is tapped and pressurized in a similar manner. Involvement of either of these closed synovial cavities mandates lavage, intrasynovial antibiotic therapy, and drainage. Regional limb perfusion with antibiotics has become an important adjunctive treatment in the management of osteomyelitis and septic arthritis.[6, 7] This technique delivers high concentrations of antibiotic to infected tissues that are poorly perfused, such as those in the distal limb. The perfusion is conducted as an initial step, before surgical intervention, in those horses with established infection of synovial structures or bone (see Chapter 80).

Sterile hoof knives[d] are helpful for thinning of the frog. A blunt probe is inserted into the puncture wound to establish the depth and direction of the tract for debridement. A 2 × 4-cm rectangular defect, centered over the puncture site, is removed from the frog and digital cushion (Fig. 67–2*B*).

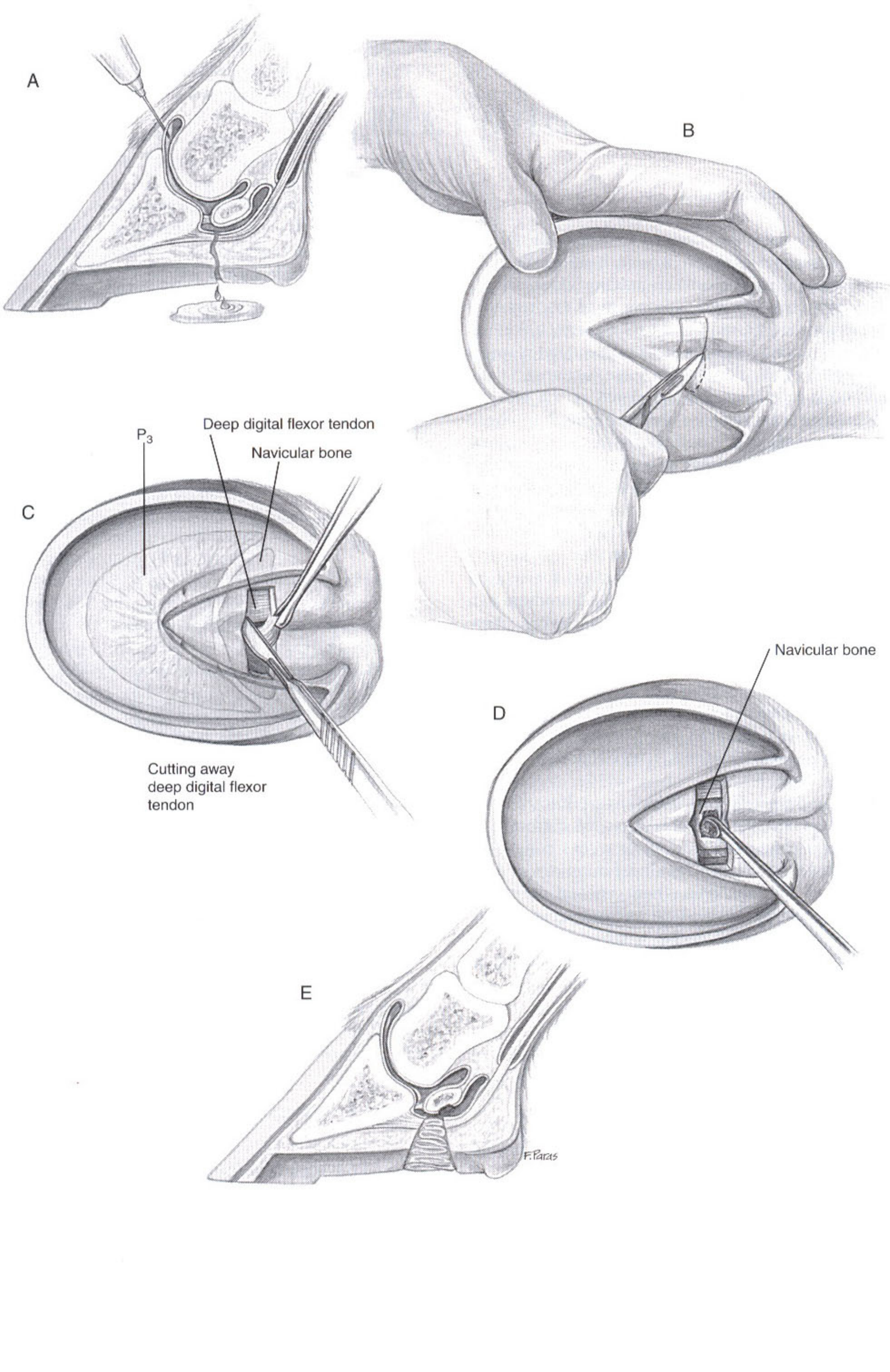
When the puncture wound penetrates the deep digital flexor tendon, which can be identified by the longitudinal arrangement of fibers, it is resected to open the navicular bursa and expose the flexor surface of the navicular bone (Fig. 67–1*C*). A 1 × 2.5-cm segment of tendon can be removed with minimal concern for tendon rupture and subsequent distal interphalangeal subluxation. This surgical exposure creates a cone-shaped defect around the puncture tract. The penetrating object can damage the navicular bone directly, discoloring or excoriating the flexor surface. Damaged areas are removed by curettage (Fig. 67–1*D*). Devitalized tendon and bone are removed and samples submitted for aerobic and anaerobic culture and antibiotic sensitivity testing. Considering the inelastic nature of the tissues and the conical shape of dissection (Fig. 67–1*E*), it can be difficult to be certain that all devitalized tissue has been removed. Scissors and small rongeurs can be helpful in trimming away the deeper margins of the defect.

The site is copiously lavaged throughout the procedure. The wound is packed with antiseptic-soaked

[c]Gentocin, Schering-Plough Animal Health Corp., Kenilworth, NJ.

[d]Hoof knife set (Aesculap-Werke, Tuttlinger, Germany), Jorgensen Laboratories, Inc., Loveland, CO.

Figure 67–2.


A
B
C
P_3
Deep digital flexor tendon
Navicular bone
Cutting away deep digital flexor tendon
D
Navicular bone
E
F. Paras

gauze (see Fig. 67–1*E*) and the tourniquet removed while pressure is maintained on the packing. If the surgeon is confident that debridement has been complete, a half-limb cast with a raised heel can be applied (see Chapter 64) as an effective way of maintaining wound hygiene and establishing immobilization during the early postoperative period. Otherwise, a sterile waterproof bandage is applied. We routinely place a plastic hoof boot over the bandage.[e]

Postoperative Management

The horse must be confined to a stall for the full duration of second-intention wound healing. Because the hoof is semirigid, wound contraction does not occur, and complete migration of corium of the frog over granulation tissue can require 2 to 3 months. If the foot has been bandaged instead of casted, bandage changes must be done aseptically. The bandage is changed daily until granulation has sealed the depth of the wound. Astringents or caustics are never applied to these wounds; they destroy germinal tissues and prolong healing. Up to 50% of these cases can require second or third debridements before healing progresses satisfactorily. Casting the limb precludes the need for bandage changes and provides immobilization but interferes with determining the need for a second debridement. Selecting the best method for wound management can be challenging. Hoof contracture can result from casting or from prolonged bandaging. Once healthy granulation tissue has formed and the corium is migrating rapidly (3–4 weeks), a hospital shoe with removable plate can be applied to simplify wound care. Premature application of the shoe, before healing is suitably advanced, can interfere with the maintenance of satisfactory wound hygiene, with deleterious effects on further healing.

Tetanus prophylaxis is administered. Parenteral antibiotics are selected on the basis of culture and sensitivity and continued for days or weeks depending on the structures involved. The longer durations of antibiotic therapy are indicated when synovial structures have been penetrated. The efficacy of parenteral antibiotics in necrotic bone or tendon is questionable. Nonsteroidal anti-inflammatory drugs are used for days or weeks depending on the severity of postoperative lameness. Those horses that become sound within 3 to 5 days after surgery and ambulate comfortably on their operated foot do not need extended antibiotic or analgesic therapy. Horses that are persistently lame require re-evaluation to determine the need for additional debridement. Repeated regional limb perfusion with antibiotics may be beneficial.[6,7]

Cases that are managed aggressively and undergo operation early can respond well and with minimal wound morbidity. When the initial surgery has been delayed, when the distal interphalangeal joint or deep digital flexor tendon sheath is involved, or when lameness persists after surgery or is poorly responsive to repeated debridements and intensive management, the prognosis is guarded. Convalescence can take 6 to 24 months before the final outcome and serviceability of the horse are known. Biotin supplementation, 15 mg/day, may benefit those cases that sustain marked hoof contraction.[8] The long-term outcome for soundness is 95% when punctures of the hoof occur outside the frog region. The prognosis is only 50% when the frog region is involved because these puncture wounds often involve synovial structures.[5] Pathologic fracture of the navicular bone and rupture of the deep digital flexor tendon are discouraging when they occur as late complications.

[e]Protect-O-Boot, Butler, Inc., Indianapolis, IN.

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chapter 68

Arthrodesis of the Proximal Interphalangeal Joint

Arthrodesis is a surgical procedure designed to hasten fusion of joint surfaces by encouraging the formation of new bone. Fusion of joints is hastened by removing cartilage, drilling holes in the dense subchondral bone plate of each of the opposing bone ends, cancellous bone grafting, and rigid fixation.[1] The purpose of arthrodesis is to eliminate pain from the joint. The indications for arthrodesis of the proximal interphalangeal joint (pastern joint) are osteoarthritis, osteochondrosis in the hind limbs, subluxation or dislocation, fractures of the proximal or middle phalanx, and palmar or plantar middle phalanx eminence fractures.[1–3] The most common indication for arthrodesis with lag screws is the treatment of osteoarthritis.[2]

Two methods of lag screw fixation have been described for arthrodesis of the proximal interphalangeal joint: (1) insertion of three parallel screws extending across the joint from the dorsal aspect of the first phalanx to the palmar or plantar aspect of the second phalanx and (2) insertion of two screws in a cruciate or crossing fashion from medial to lateral. The three-parallel-screw technique provides for a stronger fixation.[4] The original studies on arthrodesis of the proximal interphalangeal joint used 4.5-mm diameter cortical screws.[4] The 5.5-mm diameter screws have greater tensile breaking strengths and holding power in adult bone than the 4.5-mm screws and are recommended for surgical arthrodesis when available.[5] Stronger internal fixation reduces the time required for external coaptation after surgery.[3]

Arthrodesis of the proximal interphalangeal joint may also be accomplished with application of one or two bone plates. Bone plates are indicated for arthrodesis when comminuted fractures of the proximal or middle phalanx enter the proximal interphalangeal joint and lag screw fixation would not provide stability.[3]

Anesthesia, Positioning, and Surgical Preparation

Hair is removed from the coronary band to the proximal end of the metacarpal or metatarsal bone with clippers, shoes are pulled, and the hoof of the affected limb is trimmed short to remove contaminated horn. The crevices containing manure and bacteria are rasped smooth. The outside hoof wall is lightly rasped to remove the periople. The entire hoof and lower limb are scrubbed vigorously, the hoof and limb are wrapped in sterile bandages, and the hoof is placed in a plastic hoof boot.[a] If this preparation can be done on the standing horse, anesthesia time is markedly reduced. Before induction of anesthesia, broad-spectrum antibiotics and phenylbutazone are given intravenously. General anesthesia is induced, and the horse is placed in lateral recumbency with the affected limb uppermost and supported at the carpus or hock so the entire circumference of the distal limb is accessible. The dorsal aspect of the proximal interphalangeal joint is shaved, and sterile gloves are placed over the hoof and secured with tape so that 2 cm of hoof wall is exposed on the dorsal surface of the limb. The Esmarch bandage and pneumatic tourniquet are applied to just below the hock or carpus. The surgical site including the exposed part of the hoof is surgically prepared in a routine manner. The limb should be draped so that the foot is visible and can be grasped for manipulation during surgery. We recommend covering the entire distal limb with a sterile plastic adhesive barrier drape[b] and securing the drape over the hoof with sterile self-adherent bandaging material.[c] The foot is then pulled through a hole in a large impervious drape, which is secured just above the fetlock (see Chapter 3).

The procedure requires 4.5- or 5.5-mm-diameter cortical bone screws 30 to 50 mm long and the instruments needed to insert them across the joint with lag screw technique.[d] A power drill is helpful in positioning drill holes properly but not essential. A large periosteal elevator and bone curets are required. Removal of articular cartilage can be done quickly with an air-powered bone bur[e]; curets are satisfactory but

[a]Protect-O-Boot, Butler, Inc., Indianapolis, IN.
[b]Ioban 2, Animal Care Products, 3M Health Care, St. Paul, MN.
[c]3M Vetrap, Animal Care Products, 3M Health Care, St. Paul, MN.
[d]ASIF instruments and implants, Synthes (USA), Paoli, PA.
[e]Hall surgical micro 100 drill, Zimmer, Inc., Warsaw, IN.

somewhat slower. A bone chisel and mallet may be needed if the phalanges are not aligned. Equipment for intraoperative radiography and materials for cast immobilization after surgery should be available in the operating room.

Surgery

An I-shaped skin incision is made on the dorsal aspect of the distal limb centered over the proximal interphalangeal joint (Fig. 68–1*A*). The vertical part of the incision is approximately 10 cm long on a 450-kg horse and starts 1 cm proximal to the coronary band. A 6-cm-long transverse incision is made at the proximal aspect of the vertical incision, and an 8-cm-long transverse incision is made parallel to the coronary band at the distal aspect of the vertical incision. The flaps of skin and subcutaneous tissues created by the I-shaped incision are undermined with scissors, reflected, and covered with moist sponges. This step exposes the underlying digital extensor tendon and the extensor branches of the suspensory ligament. An inverted V-shaped incision is made through the extensor tendon, with the apex of the V incision 2 cm proximal to the extensor branches of the suspensory ligament. Each side of the V-shaped incision extends distally and abaxially to the lateral and medial edges of the extensor tendon and distal to the confluence of the extensor branches of the suspensory ligament for approximately 3 cm (Fig. 68–1*B*). The tendon distal to the V-shaped incision is reflected distally along with the joint capsule by a combination of sharp dissection with a scalpel blade and the use of the periosteal elevator. Reflection of this flap may be difficult in horses with extensive periarticular bone proliferation.

The proximal interphalangeal joint is flexed to open the dorsal aspect, and heavy scissors are inserted into the medial and lateral aspects of the joint to sever the collateral ligaments, further opening the joint. Forced flexion of the joint exposes the entire articular surface of both phalanges. All of the articular cartilage should be removed with a bone curet or the powered bone bur (Fig. 68–1*C*). The joint should be closed by full extension of the foot and checked to ensure good bone-to-bone contact after cartilage removal. The joint surfaces may need to be remodeled slightly to ensure good contact and alignment of the proximal and middle phalanges in a straight line. The joint is opened, and three or four 2-mm-diameter holes are drilled through the subchondral bone plate at the end of each bone in locations away from those where the screws will be placed (Fig. 68–1*D*).

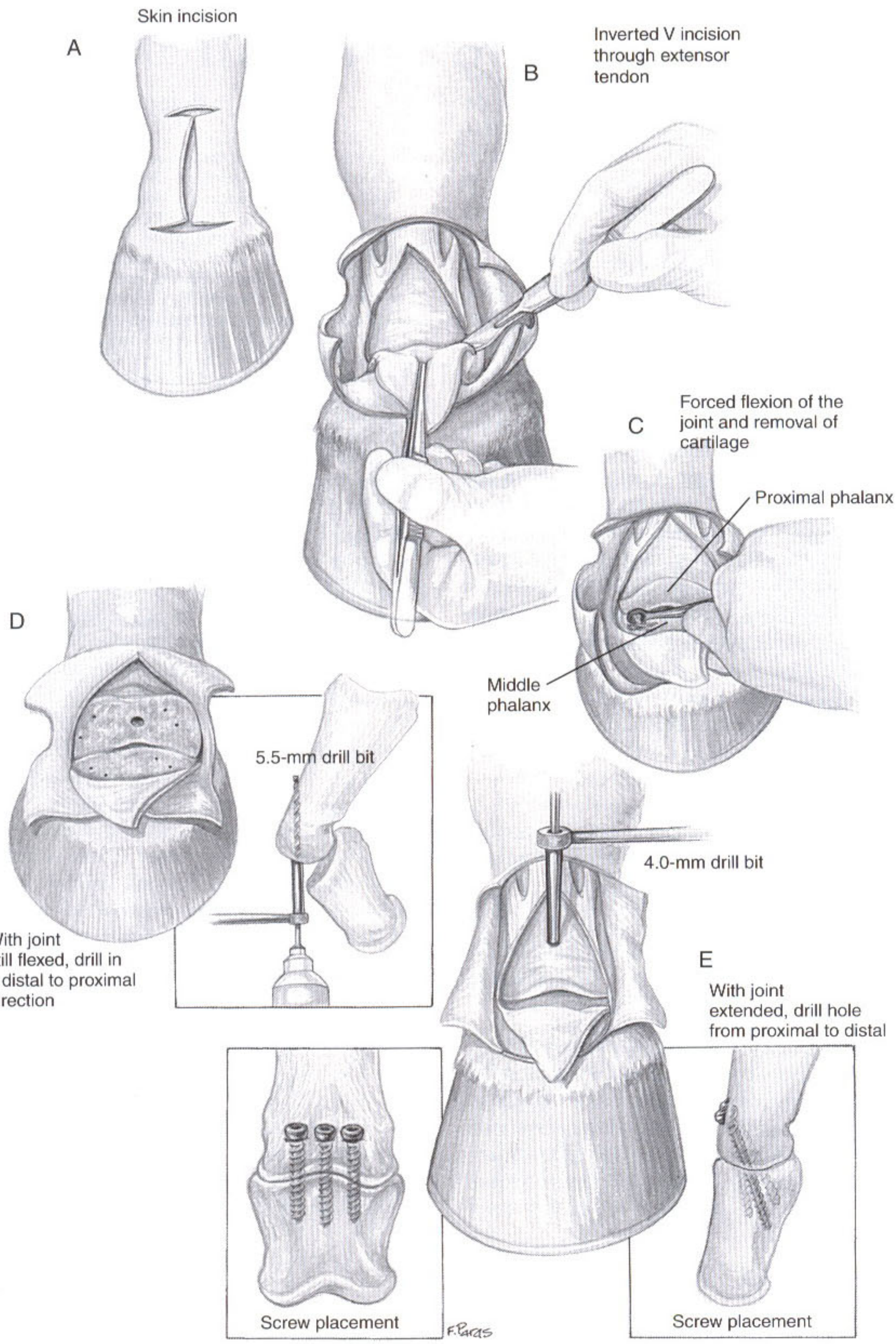
Stabilization of the joint is established by the placement of three parallel lag screws across the joint. We describe insertion of 5.5-mm-diameter screws. The gliding hole for the first screw is made with a 5.5-mm drill bit directed from a point 1 to 2 mm palmar or plantar to the center of the articular surface of the proximal phalanx in a proximal and dorsal direction so that the bit exits the dorsal surface of the proximal phalanx 1 cm proximal to the dorsal rim of the joint in a midsagittal location (see Fig. 68–1*D*).[7] The screw will be angled approximately 30° from the longitudinal axis of the proximal phalanx. The joint is realigned by extension of the foot, and the drill sleeve is inserted into the gliding hole from proximal to distal. A 4.0-mm thread hole is drilled from a proximodorsal to palmarodistal direction in the middle phalanx (Fig. 68–1*E*). Penetration of the palmar cortex of the middle phalanx should be avoided to prevent damage to the distal sesamoid ligaments, flexor tendons, or navicular bone. The length of the hole should be estimated on radiographs before surgery, and this measurement used to guide drilling. The hole is countersunk, measured, and tapped using standard lag screw technique.

A 5.5-mm screw 2 mm shorter than the measured depth is inserted, and intraoperative radiographs are taken to assess position. The end of the screw should be approximately halfway between the proximal and distal articular surfaces of the middle phalanx (see Fig. 68–1*E*). The position of the midsagittal screw is used to guide placement of the medial and lateral screws 1.5 cm apart and parallel to the first screw. Each glide hole is started with the drill directed nearly perpendicular to the proximal phalanx. As the bit engages bone, the drill is gradually angled to a position parallel to the first screw. This angle will position the drill nearly against the fetlock. The medial and lateral screws are inserted, and radiographs are taken to ensure proper screw position. We do not use a cancellous bone graft for arthrodesis of the proximal interphalangeal joint. The graft is not necessary for successful arthrodesis, adds to surgical time and postoperative morbidity, and may inhibit good contact between the proximal and middle phalanx.[3]

The V-shaped incision in the extensor tendons is closed with simple interrupted sutures placed 5 mm apart using size 0 polydioxanone[f] suture material. Subcutaneous tissue is sparse and difficult to close, but a continuous subcuticular suture pattern using size 2–0 polydioxanone can be placed at the surgeon's discretion. The skin is sutured in a routine manner. We do not use stainless steel staples because the limb will be casted, and we have noted that cast pressure on the skin can cause the staples to become imbedded in the dermis. The tourniquet is released, and a sterile wound pad and stockinette are placed on the limb followed by a half-limb fiberglass cast (see Chapter 64).

[f]PDS II, Ethicon, Inc., Somerville, NJ.

Figure 68–1.


A
Skin incision
B
Inverted V incision through extensor tendon
C
Forced flexion of the joint and removal of cartilage
Proximal phalanx
Middle phalanx
D
5.5-mm drill bit
With joint still flexed, drill in a distal to proximal direction
4.0-mm drill bit
E
With joint extended, drill hole from proximal to distal
Screw placement
Screw placement
F. Paras

Postoperative Management

A second intravenous bolus of antibiotics is given immediately after surgery. Phenylbutazone is given as needed to control pain. The opposite limb is protected and supported with a heavy bandage and a frog pad. The horse is kept in a cast for 6 or more weeks, depending on postoperative use of the limb and radiographic evidence of fusion.[1–3] The first cast should be changed in 3 to 4 weeks under general anesthesia, with subsequent cast changes done every 4 or 5 weeks. When healing is satisfactory, the last cast is removed standing, and a heavy support wrap is placed on the limb. The horse will typically be lame when the cast is first removed. Stall rest with hand walking is recommended for 3 to 4 months followed by paddock exercise, as determined by radiographic evidence of adequate bone healing. Although some horses will be sound as early as 4 months after surgery, generally 10 to 12 months is necessary for all lameness to resolve.[3, 6, 8]

Complications after surgical arthrodesis of the proximal interphalangeal joint with lag screws include infection, breakage of screws or bone, cast sores, breakdown of the opposite limb, implant-associated lameness (usually caused by misplaced screws), and toe elevation in the forelimbs.[8] Periosteal new bone formation may impinge on the distal interphalangeal joint, particularly after arthrodesis for fracture repair. Despite these complications, a successful outcome in the forelimbs ranges from 46 to 67% and in the hind limbs from 83 to 86%.[6, 8, 9]

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chapter 69

Palmar-Plantar Annular Ligament Division

The digital sheath envelopes the superficial and deep digital flexor tendons from the level of the bifurcation of the suspensory ligament to the level of the middle phalanx.[1] At the level of the fetlock joint, the sheath and tendons pass through the inelastic fetlock canal, which is formed by the sesamoid bones, intersesamoid ligament, and palmar or plantar annular ligament. The tendon sheath adheres to the annular ligament, and the two appear as one structure ultrasonographically. Compression of the flexor tendons, restriction of free movement of the tendons from stenosis of the canal, and swelling of structures within the canal cause lameness. This problem has frequently been termed constriction of the palmar or plantar annular ligament. However, this term is not descriptive for all the causes of fetlock canal–associated lameness. Currently, it is believed that compression and restriction of movement of the tendons through the inelastic fetlock canal can be caused by contraction of the annular ligament after direct trauma, desmitis of the annular ligament, digital flexor tendinitis accompanied by swelling of the tendons, chronic synovitis of the tendon sheath, adhesions between the sheath and the tendons, and combinations of these lesions.[1–3] Trauma and, less commonly, sepsis initiate the disease. Division of the palmar or plantar annular ligament is the most effective method of treating lame horses with compression of the digital tendons within the fetlock canal. The procedure eliminates the pressure created by the restrictive inelastic canal that envelopes the tendons.

Horses with stenosis of the fetlock canal usually exhibit chronic lameness that is exacerbated with exercise. The affected limb has effusion in the digital tendon sheath, is positive to a distal limb flexion test, and has a characteristic clinical appearance when viewed from the side that has been described as a "notch" or hourglass appearance on the palmar (plantar) aspect of the fetlock.[2] The notch is formed by swelling or thickening of the digital tendon sheath proximal and distal to the inelastic annular ligament, creating a constricted or depressed area on the back of the fetlock at the level of the annular ligament. Intrathecal anesthesia usually improves the lameness. The flexor tendons, digital sheath, annular ligaments, and fetlock canal should be evaluated by ultrasonography before surgery to determine the cause of the compression, size and structure of the tendons, and thickness of the sheath and to detect adhesions and nodular masses within the sheath. When adhesions or core lesions in the tendons are present, the fetlock canal should be opened during annular ligament transection to allow division of adhesions and splitting of the affected tendon.[2] The fetlock canal does not have to be completely opened in the absence of adhesions or core lesions, and a more limited incision with blind transection of the annular ligament can be done.

Anesthesia, Positioning, and Surgical Preparation

Perioperative antibiotics are administered. The horse is anesthetized and positioned in lateral recumbency with the affected limb uppermost. An Esmarch bandage may be placed on the limb to reduce hemorrhage but is not essential. A routine skin preparation for aseptic surgery is performed from the coronary band to the distal carpus or tarsus.

Surgery

Open Transection

When the tendon sheath is to be opened completely to expose the tendons, an 8- to 10-cm-long vertical incision through the skin and subcutaneous tissues is made directly over the annular ligament. The incision is parallel to the tendons and neurovascular structures. The incision is made midway between the neurovascular structures and the midsagittal aspect of the fetlock (Fig. 69–1*A*). An incision on the palmar or planter midline will disrupt the normal sagittal attachment of the superficial digital flexor tendon to the tendon sheath and annular ligament.[1] An incision too far lateral will encroach on the sesamoid bone or the neurovascular structures.[3] At the proper location, the incision will be just axial to the palpable palmar-plantar edge of the sesamoid bone.

The tendon sheath is opened at the proximal border of the annular ligament with a 1-cm incision. Synovial fluid will escape from the incision, confirming entrance into the sheath. A curved instrument such as Metzenbaum scissors, Ochsner forceps, or Carmalt forceps is inserted into the sheath and passed distally through the fetlock canal until the tip is just distal to the distal edge of the annular ligament (Fig. 69–1*B*). The instrument is palpated under the annular ligament to verify a satisfactory plane of transection of the ligament. The entire ligament and the attached tendon sheath are then transected with a scalpel blade by cutting down to the instrument. Care is taken not to damage the underlying tendons. Adhesions of the tendon to the sheath are transected, and nodular synovial membrane masses are excised. The tendons are inspected. Tendon splitting of the deep digital flexor tendon can be performed if core lesions have been identified by ultrasound before surgery.[2] The tendon sheath is lavaged with sterile fluids. The annular ligament and attached tendon sheath are not closed. The subcutaneous tissues are closed with size 2–0 polydioxanone[a] suture material placed in a simple continuous or simple interrupted pattern. The interrupted pattern is recommended because it is less prone than a continuous pattern to disruption from fetlock motion during the postoperative period. The skin is closed with 2–0 monofilament nonabsorbable suture material.

Closed Transection

When the tendons or sheath within the fetlock canal does not need to be exposed, a much smaller incision into the tendon sheath can be made and the annular ligament is transected blindly. This technique decreases the risk of postoperative dehiscence and synovial fistula formation.[4] A 2-cm incision is made through the skin and into the digital tendon sheath just above the proximal edge of the annular ligament (Fig. 69–1*C*). The incision is made in the same location as the incision for open transection. Synovial fluid will escape to confirm entry into the sheath. A groove director is inserted into the tendon sheath and down the fetlock canal until the end can be palpated just distal to the distal edge of the annular ligament (Fig. 69–1*D*). A tendon splitting knife[b] or tenotome knife[c] is passed down the groove director to the distal edge of the ligament. The knife, positioned with the cutting edge superficially, is used to transect the annular ligament in a distal to proximal direction. The skin over the ligament should not be incised. Palpation with a finger placed on the skin is used to determine when the tenotomy knife has transected the ligament and is directly under the skin (Fig. 69–1*E*). Alternatively, a subcutaneous tunnel over the site of annular ligament transection can be made with Metzenbaum scissors, and the annular ligament is blindly transected with scissors positioned so that one blade is in the sheath and one blade is in the subcutaneous tissues.[4] Before transection, the distal limit of the annular ligament must be well defined by the surgeon so that the entire ligament is transected. The tendon sheath can be flushed with sterile fluids, and the incision in the tendon sheath directly beneath the skin incision is closed with size 2–0 polydioxanone suture material in a simple continuous pattern. Subcutaneous tissues and skin are closed routinely.

After closure, the tendon sheath may be injected with sodium hyaluronate.[4] A sterile support bandage is placed over the surgical site.

Postoperative Management

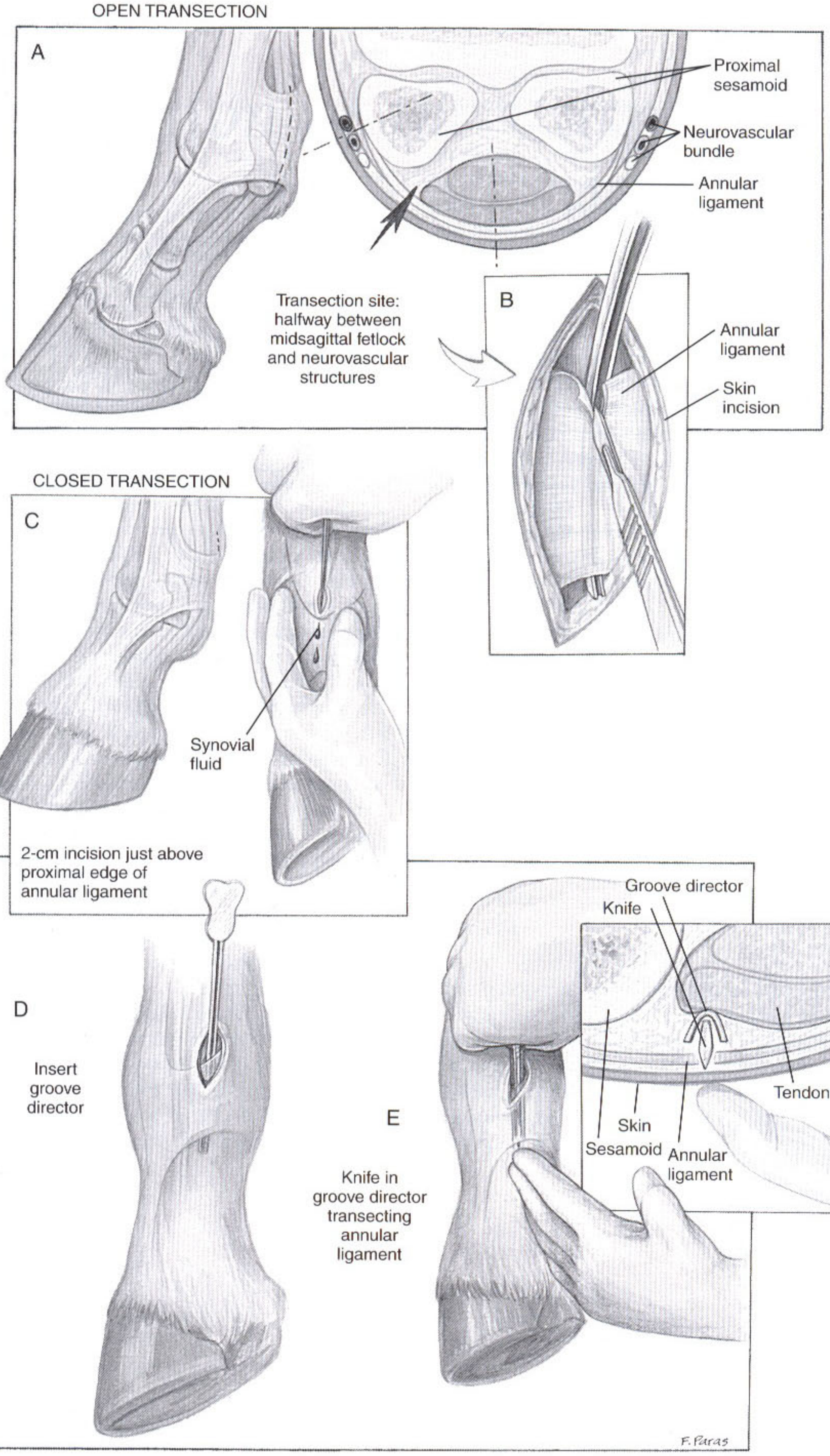
In the absence of pre-existing infection, antibiotics are limited to the perioperative period. Phenylbutazone is administered to control inflammation for 10 days. Intrathecal sodium hyaluronate can be repeated in 10 to 14 days in horses in which adhesions in the tendon sheath were transected. Bandages should be maintained for 3 to 4 weeks.[2] Stall rest without exercise is recommended for 9 to 10 days, after which hand walking can begin. Frequent periods of walking may reduce the formation of new restrictive adhesions. Regular exercise can resume 4 to 6 weeks after surgery for horses without tendon lesions or adhesions. Paddock rest may be prolonged for months in horses with severe tendinitis, adhesions, or tenosynovitis. Serial ultrasound examinations should be used to monitor the convalescence in such cases.

[a]PDS II, Ethicon, Inc., Somerville, NJ.

[b]Tendon splitter, Jorgensen Laboratories, Inc., Loveland, CO.

[c]Tenotome knife, blunt curved, Jorgensen Laboratories, Inc., Loveland, CO.

Figure 69–1.


OPEN TRANSECTION
A
Proximal sesamoid
Neurovascular bundle
Annular ligament
Transection site: halfway between midsagittal fetlock and neurovascular structures
B
Annular ligament
Skin incision
CLOSED TRANSECTION
C
Synovial fluid
2-cm incision just above proximal edge of annular ligament
D
Insert groove director
E
Knife in groove director transecting annular ligament
Groove director
Knife
Tendon
Skin
Sesamoid
Annular ligament
F. Paras

Synovial fistulas, wound dehiscence, and septic tenosynovitis are possible complications associated with annular ligament transection. These complications appear more prevalent after the open transection technique.[4] The prognosis for soundness depends on the condition of the tendons and the number of adhesions. Horses with fetlock canal stenosis or constriction not associated with tendinitis or adhesions have a good prognosis for return to work.[5] Horses with severe tendon lesions and marked adhesion formation have a poor prognosis.

As an alternative to standard surgery, annular ligament transection may be performed using endoscopic guidance.[6] Small incisions into the tendon sheath can be used to evaluate the tendons endoscopically, remove synovial masses, transect adhesions, and transect the annular ligament. The advantages of endoscopic surgery are greater when multiple lesions are present.[6] Endoscopic surgery requires special equipment and skills and a thorough knowledge of endoscopic anatomy.

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chapter 70

Resection of the Carpal Flexor Retinaculum

The carpal canal is located on the palmar aspect of the carpus. The superficial digital flexor tendon, the deep digital flexor tendon, the carpal synovial sheath, the medial and lateral palmar artery and vein, and the medial palmar nerve pass through it.[1] The canal is formed by the common palmar ligament of the carpus, the flexor retinaculum of the carpus, the accessory ligament of the superficial digital flexor tendon, and the accessory carpal bone. The carpal canal is inelastic and cannot distend or increase in cross-sectional area. Compression of the structures within this nondistensible canal causes pain. Compression may be due to a reduction in the size of the carpal canal, pressure from a space-occupying mass in the canal, or swelling of structures within the canal. Causes of carpal canal pain include traumatic tenosynovitis, infectious tenosynovitis, digital flexor tendinitis, osteochondroma of the distal radius, traumatic hyperextension of the carpus, and fracture of the accessory carpal bone.[2–4] Many of these diseases can be treated with rest and medical therapy. Persistent lameness from thickening and swelling of structures within the canal or from narrowing of the canal caused by swelling and fibrosis of the surrounding walls may require resection of an elliptic segment of the carpal flexor retinaculum to effect improvement. This surgery reduces compression on the tendons, vessels, and nerves that pass through the canal.

The clinical signs of horses with pain resulting from compression of structures within the carpal canal have been termed carpal canal syndrome.[3] Horses may be intermittently or continuously lame, and most horses have distention of the carpal synovial sheath. Reduced carpal flexion with pain on flexion is common. Intrathecal injection of local anesthetic into the carpal synovial sheath will decrease the lameness. Radiographs of the carpus should be taken to detect fractures of the accessory carpal bone and osteochondromas.

Osteochondromas can be removed. Many fractures of the accessory carpal bone heal with a fibrous union, after which the carpal canal pain subsides.[2] However, lameness 6 to 8 months after fracture, extensive callus formation, and signs of carpal canal pain support the need for resection of the carpal retinaculum. Ultrasonography is recommended to evaluate the flexor tendons and the carpal synovial sheath and to detect intrathecal masses.[4] The condition of structures within the carpal synovial sheath will determine whether the synovial sheath needs to be opened during resection of the flexor retinaculum.

Anesthesia, Positioning, and Surgical Preparation

Perioperative antibiotics are administered at the discretion of the surgeon and are often used when the surgeon anticipates opening the carpal synovial sheath. The horse is anesthetized and positioned in lateral recumbency with the affected limb down. The skin is prepared over the medial aspect of the carpus for aseptic surgery, and the surgery site is routinely draped.

Surgery

A 12-cm longitudinal incision through the skin and subcutaneous tissues is made parallel and palmar to the common digital vein on the palmaromedial aspect of the carpus (Fig. 70–1*A*). The incision extends from 3 cm above to 5 cm below the accessory carpal bone.[5] The carpal flexor retinaculum is incised between the medial palmar vein and radial artery dorsally and between the lateral palmar artery, vein, and nerve palmarly (Fig. 70–1*B*). These vessels are covered by or imbedded within the carpal flexor retinaculum and need to be identified and preserved.[3] A ½- to 1-cm-wide elliptic strip of retinaculum is excised over the length of the compressed area, which is 8 to 10 cm long and centered at the accessory carpal bone (Fig. 70–1*C*). Adhesions between the carpal flexor retinaculum and the carpal synovial sheath are transected. The synovial sheath is opened with a longitudinal incision when preoperative ultrasonography reveals adhesions, masses, or severe tendon lesions within the sheath that need inspection (Fig. 70–1*D*).[3] The medial palmar artery and nerve should be identified and protected. The nerve should be freed of any fibrous adhesions.[3] The tendon sheath and carpal canal are lavaged with polyionic solution, and the subcutaneous tissues are closed with a simple interrupted or simple continuous suture pattern using size 2–0 polydioxanone[a] suture material. Closure should be meticulous and secure to prevent synovial leakage from the carpal synovial sheath. The skin is closed routinely. A firm sterile full-limb bandage is applied.

Postoperative Management

The second injection of perioperative antibiotics can be administered intravenously within 3 or 4 hours of completion of the surgery. Nonsteroidal anti-inflammatory drugs such as phenylbutazone or flunixin meglumine[b] should be given for 3 to 5 days, depending on the degree of pain and inflammation at the surgery site. The skin sutures are removed 7 to 9 days after surgery, and the bandage is maintained for 2 to 3 weeks. The bandage is changed as needed. Walking should start 4 days after surgery to reduce the formation of restrictive adhesions within the carpal canal. Resumption of exercise depends on the cause of the carpal canal pain. Exercise can resume in 4 to 6 weeks for horses with chronic inflammation and thickening of the tendon sheath or with swelling resulting from a healed accessory carpal bone fracture. Exercise may be delayed for many months in horses with active tenosynovitis, severe tendon lesions, or unhealed accessory carpal bone fractures.

Complications after surgery include infection of the carpal synovial sheath, synovial fistula, continued tenosynovitis, adhesions, and poor relief of pain.[3,4] The prognosis for horses with severe lameness and marked changes in the structures within the carpal canal is guarded.[4] Horses with slight to moderate lameness caused by compression of structures within the canal or with pain from chronic accessory bone fractures often improve quickly after resection of the palmar carpal retinaculum and may become sound for riding or racing.[5]

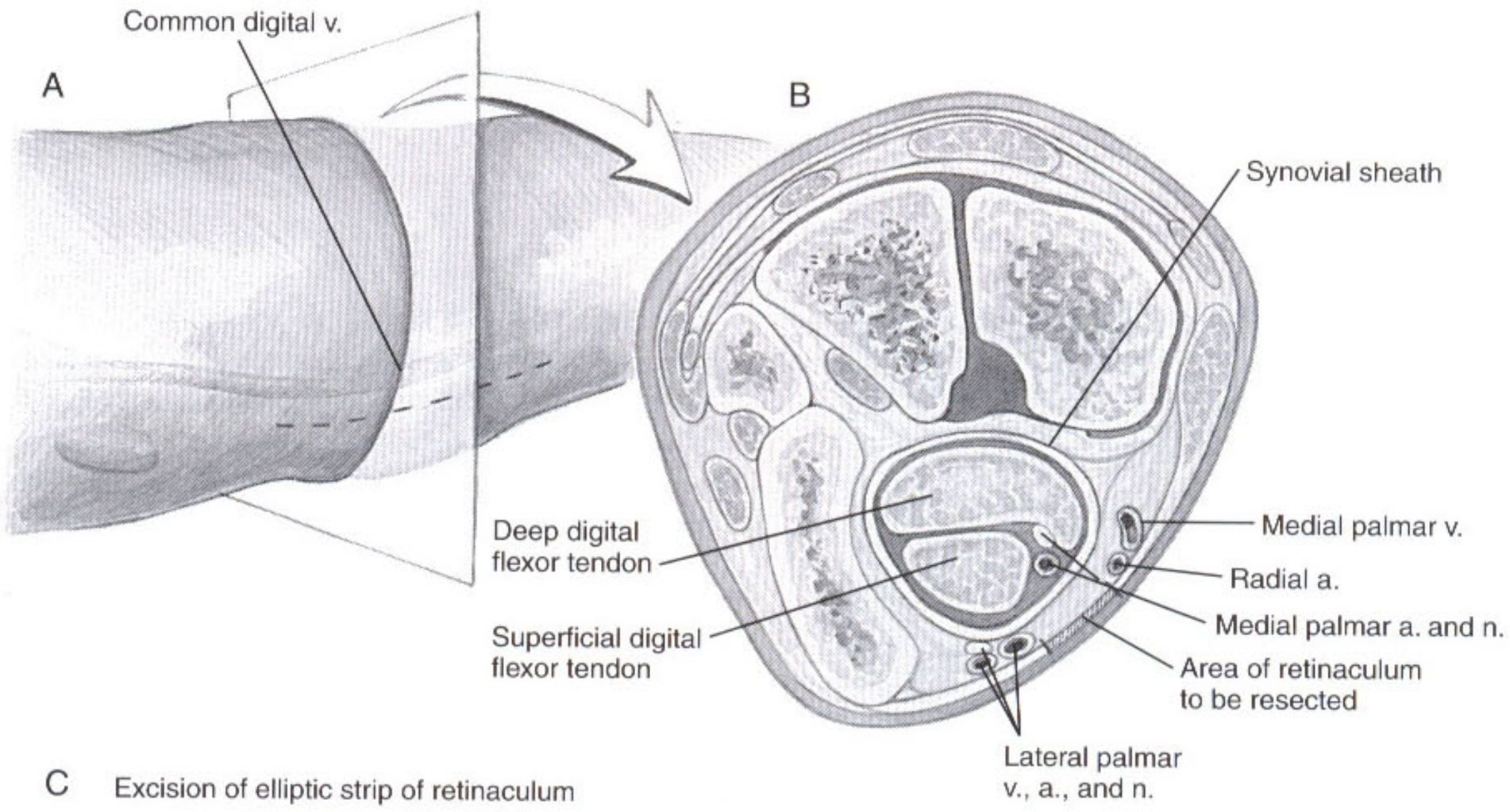
[a]PDS II, Ethicon, Inc., Somerville, NJ.

[b]Banamine solution, Schering-Plough Animal Health Corp., Kenilworth, NJ.

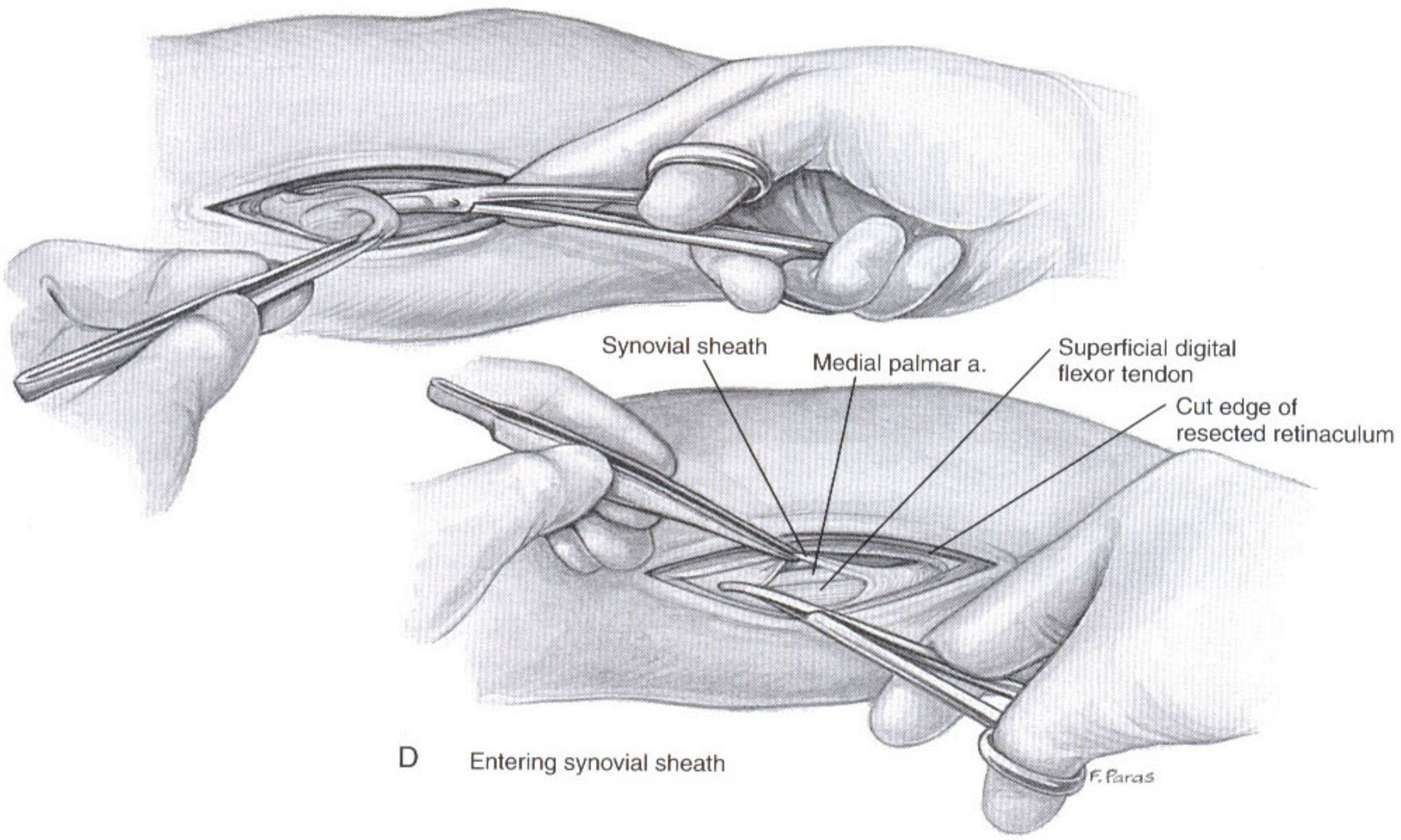
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Figure 70–1.



C Excision of elliptic strip of retinaculum



D Entering synovial sheath

chapter 71

Distal Check Desmotomy

The management of acquired flexural limb deformities in suckling, weanling, and yearling horses can be complex. Pain resulting from a variety of causes in young horses (e.g., wounds, osteochondrosis, physitis) induces the pain withdrawal reflex and leads to flexural limb deformity. Overfeeding associated with a lack of exercise may contribute to physitis as a common syndrome associated with flexural limb deformities.[1] Careful examination of the affected limb, under weight bearing and passively with the limb picked up, helps to establish which anatomic structures are involved and aids in the selection of treatment. Conservative therapy, including nutritional management, nonsteroidal anti-inflammatory drugs, corrective hoof trimming, and exercise, can be successful when instituted early and aggressively. Horses with prolonged flexural deformity have secondary joint capsule, collateral ligament, or suspensory apparatus contracture. The involvement of these structures, compared with the flexor muscles themselves, detracts from a favorable outcome regardless of the approach to treatment.

The accessory (check) ligaments of the flexor tendons provide unique bone-tendon-ligament-bone connections in the equine forelimbs. These connections are part of the stay apparatus at rest and prevent metacarpophalangeal and interphalangeal joint hyperextension in the presence of flexor muscle fatigue. Accessory ligaments may prevent normal joint extension when the posture has been modified by flexural deformity. Desmotomy of the accessory ligament of the deep digital flexor tendon (distal check ligament) is a well-established procedure for the treatment of flexural limb deformities involving the metacarpophalangeal and distal interphalangeal joints. Distal check desmotomy is the surgical treatment of choice for contraction of the deep digital flexor muscle with so-called clubfoot in younger foals (Fig. 71–1). It is excellent for horses with flexural deformity of the distal interphalangeal joint when the dorsal hoof angle is 90° or less and may be useful for horses with a hoof angle greater than 90°. Yearling horses that knuckle forward in the metacarpophalangeal joint as a result of deep digital flexor contraction may respond favorably to distal check desmotomy. Surgery is indicated when conservative management for 10 to 14 days has failed. Because the risk-benefit ratio for this surgery is favorable, some surgeons perform the procedure initially as a "conservative approach." The surgery should be done before 6 months of age for the best long-term results.[2–4]



Figure 71–1.

A 5-month-old filly with a clubfoot. The hoof has been trimmed and the heel will not extend to the ground, making the animal an excellent candidate for distal check desmotomy.

Anesthesia, Positioning, and Surgical Preparation

Horses with a clubfoot can sustain subsolar abscesses of the toe. These abscesses should be treated and healing before distal check desmotomy is performed. Because venous and lymphatic drainage from the foot traverses the surgery site, infection should be resolved beforehand. Hoofs are trimmed before or at the time of surgery. The heels of clubfooted horses are shortened to improve phalangeal alignment. General anesthesia is required, and the horse is positioned in lateral recumbency. If a single limb is involved or if the surgeon is experienced with the procedure, extended intravenous anesthesia is acceptable. We frequently encounter cases requiring bilateral surgery and prefer inhalation anesthesia. One limb can be approached laterally and the other limb medially without repositioning the horse. Hair around the full circumference of the limb is clipped from just above the carpus to the fetlock, and the incision site is routinely prepared for aseptic surgery. It is helpful to scrub the full circumference of the limb and to use a self-adhering impervious drape[a] so that the surgeon can palpate the flexor structures through the skin intraoperatively, particularly when using the medial approach. In the absence of pre-existing foot infection, perioperative antibiotics are unnecessary. No special instruments are required.

Surgery

A 6-cm incision, centered between the proximal and middle thirds of the metacarpus, is made directly over the deep digital flexor tendon. Sharp dissection is continued through the subcutaneous tissue and paratenon of the deep digital flexor tendon (Fig. 71–2*A*). Orientation of the incision is aided by stabilization of the flexor tendons with the fingers of the surgeon's opposite hand (see Fig. 71–2*A*).

The superficial digital flexor and deep digital flexor tendons can be identified, but they should not be separated by the dissection. Hemorrhage is controlled with hemostats. Blunt dissection should be minimized to avoid postoperative seroma formation and excessive scarring. Retraction of the paratendon exposes the cleavage between the deep digital flexor tendon and the distal check ligament. From the lateral approach, the metacarpal neurovascular bundle is adjacent but dorsal to the plane of dissection and should not interfere with the identification of the check ligament (Fig. 71–2*B*). From the medial approach, the neurovascular bundle is directly over the deep digital flexor tendon and must be reflected and retracted dorsally to proceed with the dissection (see Fig. 71–2*B*). Also the distal check ligament is oriented laterally but has a semilunar configuration on the medial side that wraps around the deep digital flexor tendon, displacing the cleavage between these structures to the palmar aspect of the tendon (see Fig. 71–2*B*). Attention to these two differences from the lateral approach reduces the tediousness that can accompany the medial approach.

The distal check ligament is separated from the deep digital flexor tendon by using curved Kelly or Crile forceps to isolate and bluntly separate the structures. Separation of these structures in the distal aspect of the surgical field usually avoids inadvertent opening of the carpal flexor synovial sheath. The check ligament is elevated from the wound bed over the forceps and transected with a scalpel (Fig. 71–2*C*). The distal check ligament may be larger than the deep digital flexor tendon, particularly in younger horses. The patient's foot is extended, and the gap between the severed ends of the check ligament is palpated to make certain that the full thickness of the structure has been transected. Complete transection should result in a gap 1 cm or larger. Because of the semilunar configuration of the distal check ligament and when performing the surgery from the lateral side, it is not uncommon to leave a small bundle of remaining fibers on the medial side. These fibers must be identified and severed. Some surgeons remove a 1- to 2-cm segment of distal check ligament, but there is no evidence to support the need to do so.

The paratenon and subcutaneous fascia are closed together as a single layer using a simple continuous pattern. We prefer to approximate the dermis with intradermally placed sutures and close the skin with stainless steel staples[b] or interrupted sutures. A size 3–0 delayed-absorbable monofilament synthetic suture material such as polydioxanone[c] provides sufficient strength for the paratenon and subcutaneous tissues. Excessive blunt dissection, the use of larger than necessary suture material, poor apposition of the skin, opening of the carpal synovial sheath, and excessive postoperative exercise may lead to an objectionable amount of scar tissue and blemish.

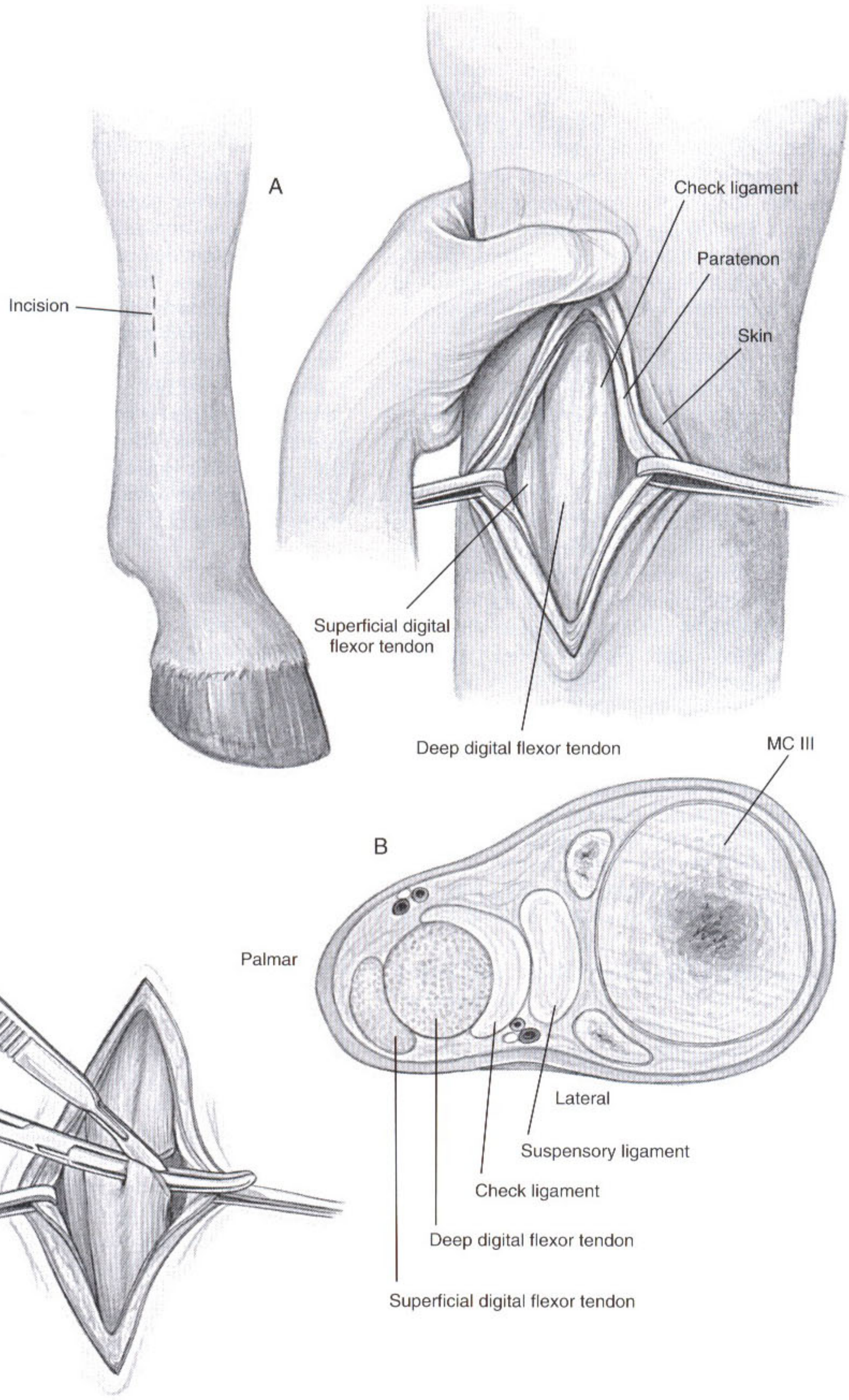
Ultrasound-guided transection of the distal check ligament has been described.[2] The procedure is reported to be less invasive and is associated with a reduced postoperative wound morbidity. This surgery requires an ultrasound machine and an assistant to hold the transducer; however, it can be done with the horse standing.

[a]Ioban 2, Animal Care Products, 3M Health Care, St. Paul, MN.

[b]Appose ULC, Davis & Geck, Inc., American Cyanamid Co., Manati, PR.

[c]PDS II, Ethicon, Inc., Somerville, NJ.

Figure 71–2.


A
Incision
Check ligament
Paratenon
Skin
Superficial digital flexor tendon
Deep digital flexor tendon
MC III
B
Palmar
Lateral
Suspensory ligament
Check ligament
Deep digital flexor tendon
Superficial digital flexor tendon
C

Postoperative Management

The limb is bandaged from the hoof to the carpus with sterile dressing materials before the horse is moved to recovery. The bandage is not reset for 3 to 4 days unless dirty, wet, or displaced. Support bandaging is continued for a minimum of 2 weeks, preferably up to 30 days. Phenylbutazone, 2.2 mg/kg b.i.d., is administered as an anti-inflammatory to control the pain withdrawal reflex. Depending on the postural improvement in the limb after surgery, this medication is continued for up to 5 days. The dosage and duration of phenylbutazone administration should be minimized, particularly in young foals that are predisposed to gastric ulcers. The tetanus immunization status should be current.

Nutritional modification in young, growing animals, adjustment in the exercise regimen, and corrective foot trimming are essential components of the management of flexion deformities after surgery. Fast-growing nursing foals with evidence of physitis may need to be weaned. Limiting the feeding to grass hay and water for 30 days, to "stunt" rapid growth, has been recommended in certain circumstances.[1] Horses that have been confined should be exercised or turned out in a paddock. Hand walking can be started 3 to 5 days after surgery and the exercise increased after suture removal. Acrylic toe-caps,[d] glue-on shoes,[e] or other types of toe extensions should be applied to foals with worn toes or misshapen feet. It may be necessary to rasp the heels as frequently as twice weekly to compensate for the clubfoot as a new hoof capsule grows out. When the pain has been relieved with phenylbutazone, extension of the toe induces the inverse myotatic reflex with further relaxation of the deep digital flexor muscle.

[d]Technovit, Jorgensen Laboratories, Inc., Loveland, CO.
[e]Baby-Glu therapeutic horseshoes, Glu-Strider, Bloomfield, CT.

White hair along the incision line, infection, seroma formation, and the development of an objectionable blemish are the complications that can follow this surgery. They can be reduced or eliminated by operating at an early age, by using aseptic and atraumatic technique, by applying a pressure bandage, and by administering phenylbutazone during early convalescence. Some surgeons prefer to operate from the medial side so that the resultant blemish is less noticeable, but we believe that the amount of scar tissue and blemish is negligible when careful technique and proper postoperative care are applied. In any event, the complications from a persistent deformity are more common and more serious than those from surgery.

The prognosis for distal check desmotomy is good to excellent when the indications for surgery are correct. Most horses sustain an improved conformation within 24 to 36 hours of surgery. Two different long-term studies report a good prognosis for horses that are operated on when younger than 6 months; many reach their full athletic potential after this surgery.[3, 4] Although correction of the deformity in older horses is possible, some steepness of the hoof wall may remain.[2, 4]

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chapter 72

Proximal Check Desmotomy/ Percutaneous Tendon Splitting

Desmotomy of the accessory ligament (proximal check desmotomy) is used in the surgical management of diseases of superficial digital flexor tendons and, rarely, in the management of conformational defects of the carpus. Flexural limb deformities in yearling horses, with forward knuckling of the metacarpophalangeal joint, may result from contraction of either the deep digital flexor or the superficial digital flexor musculotendinous unit. When the physical examination indicates involvement of the superficial digital flexor, proximal check desmotomy may be useful in the treatment. Some horses require both distal and proximal check desmotomies to effect improvement.[1] The surgeon and the owner need to be prepared for subsequent operations if the first procedure is not completely successful. Because it is impossible to determine the degree of postural improvement by passive manipulation of the affected limb with the horse anesthetized, it is important to perform a single procedure at a time in horses with mild flexural deformities. We perform check desmotomies before resorting to tenotomies, which have a poorer prognosis for future athletic soundness.

Proximal check desmotomy is being used in the management of superficial digital flexor tendinitis in racehorses.[2] Such tendon injuries heal with scar tissue that is devoid of the elastic function that is normally present. The check ligament normally sets the elastic limit of the tendon. Desmotomy of the accessory ligament of the superficial digital flexor releases the bone-tendon-ligament-bone restriction, allowing the muscle belly to contribute to the overall elasticity of the previously injured musculotendinous unit. After surgery, the check ligament heals with a more proximal attachment to the tendon. This surgical modification of superficial digital flexor function may improve the success rate of horses returning to racing compared with the nonsurgical treatment of superficial digital flexor tendinitis.[3, 4]

Because the clinical signs and lameness do not always correlate with the severity of a superficial digital flexor tendon injury, ultrasound evaluation of both forelimbs is essential for selecting candidates for surgery and for monitoring tendon healing during convalescence. Tendon lesions are frequently detected bilaterally with ultrasonography even though the clinical signs are confined to one limb.[2] Bilateral proximal check desmotomies are warranted in such cases, or the procedure is performed bilaterally as a preventive because of the tendency for horses to sustain tendinitis bilaterally.

In addition to proximal check desmotomy, two other procedures are used in the surgical management of tendinitis: tendon splitting and annular ligament desmotomy (see Chapter 69). When monitored by ultrasonography, some horses sustain increasing tendon fiber damage with increasing sonolucency of the core lesion over the first 10 days after tendon injury.[2] This early progression of the lesion may be caused by pressure necrosis from the intramural hematoma and the action of proteolytic substances released from injured tenocytes. Tendon splitting drains the core lesion, reduces the pressure, and creates a communication between the tendon core and the peritenon that promotes resolution of the inflammation and subsequent healing.[5, 6] Tendon splitting can be performed on the standing horse or at the same time as proximal check desmotomy, about 10 to 14 days after the initial injury.

Anesthesia, Positioning, and Surgical Preparation

Proximal check desmotomy requires meticulous dissection and hemostasis; the operated limb needs to be stationary. Inhalation anesthesia is required. The horse is positioned in lateral recumbency with the affected limb down. When both legs are to be operated on, the horse may be positioned in dorsal recumbency. We prefer to reposition the horse for the second limb rather than using dorsal recumbency. The hair on the limb is clipped from the elbow to the midmetacarpus, and excess keratin is removed from the chestnut. If tendon splitting is to be done at the same time, the limb is clipped to below the fetlock. The medial aspect of the forearm and carpus is routinely scrubbed for aseptic surgery. The surgery is performed without a tourniquet. Suction and cautery should be available. Two Gelpi

self-retaining retractors[a] are the only special instruments required. Perioperative antibiotics are not used routinely.

Surgery

Proximal Check Desmotomy

A scalpel is used for all incisions and transections. A 10-cm incision, centered next to the chestnut and extending from the medial distal physis of the radius proximally, is made between the cephalic vein and the caudal border of the radius directly over the flexor carpi radialis tendon (Fig. 72–1*A*). In some horses, the cephalic vein is directly beneath the incision site. Sharp dissection is continued through the subcutaneous tissue until the perforating branch of the cephalic vein and its oval foramen in the antebrachial fascia are identified (see Fig. 72–1*A*). The perforating branch usually requires division between ligatures to aid caudal retraction of the cephalic vein. The antebrachial fascia is incised 1 cm caudal to the radius, exposing the tendon of the flexor carpi radialis within its sheath. Dissection beyond this point requires a dry field; hemostasis should be complete before proceeding.

The thick fascia of the flexor carpi radialis tendon sheath is incised to expose the white, glistening tendon within (Fig. 72–1*B*).[7, 8] Using a grooved director or forceps to guard the tendon, the sheath is opened for 6 to 8 cm (see Fig. 72–1*B*). Two Gelpi retractors are positioned in the sheath to retract the flexor carpi radialis tendon caudally, thus exposing the deep (lateral) aspect of the tendon sheath (Fig. 72–1*C*). The normally wide, indistinct margins of attachment of the proximal check ligament to the radius are better defined a short distance caudal to the radius and are usually palpable through the lateral aspect of the tendon sheath (see Fig. 72–1*C*).[7] A curved Kelly forceps or vascular clamp[b] is inserted through the tendon sheath and under the borders of the check ligament and spread.

Careful fiber-by-fiber transection of both the sheath and the check ligament over forceps is performed in a proximal direction (Fig. 72–1*D*). The proximal portion of the check ligament may be flaccid during surgery; failure to transect this portion of the ligament will nullify the effects of surgery in that the check ligament will heal with scar tissue replacement without lengthening. A nutrient artery for the superficial digital flexor tendon may course through this proximal flaccid portion of check ligament along the direction of its fibers. Careful fiber-by-fiber dissection will avoid severing the artery and its accompanying vein.[1, 7] Distally, the carpal canal is adjacent to the flexor carpi radialis tendon sheath and check ligament. The boundaries of these structures may be indistinct, particularly in Standardbreds. The carpal canal is frequently entered when the check ligament is completely transected. Fiber-by-fiber transection of the check ligament will help to avoid the palmar carpal rete vessels that are associated with the carpal canal and the palmar distal aspect of the radius. When proximal check ligament transection is complete, the superficial digital flexor tendon and its nutrient artery may be visible in the incision proximally, the muscle belly of the radial head of the deep digital flexor will be visible centrally, and the carpal synovial sheath and palmar carpal rete will be visible distally.

The incision is lavaged and suctioned, and final hemostasis is established before closure. The antebrachial fascia and superficial (medial) layer of the flexor carpi radialis tendon sheath are closed as the first layer with interrupted sutures of size 2–0 polydioxanone.[c] The subcutaneous tissues are closed as a second layer with a simple continuous suture using size 3–0 polydioxanone. The skin is carefully apposed with a continuous intradermal stitch using size 3–0 polydioxanone, followed by simple interrupted sutures using size 2–0 polypropylene[d] or stainless steel staples.[e] A sterile, heavily padded pressure bandage is applied from the foot to above the incision before proceeding with surgery on the opposite leg or before recovering the horse from anesthesia.

Tendon Splitting

Percutaneous tendon splitting can be performed on the standing horse using chemical restraint and regional perineural anesthesia or under general anesthesia. Controlled incision into the core lesion of the tendon is easier with the structure under tension in the standing horse. In either event, the procedure is performed aseptically. The surgeon locates the region of the core lesion, stabilizes the tendon with one hand, and stabs through the skin with a double-edged tendon-splitting knife[f] (Fig. 72–1*E*). Ultrasonography can be used to accurately position the knife in the core lesion. The knife is passed to the peritenon on the opposite side of the tendon. If the core lesion is eccentric within the tendon, the stab incision is made from the normal side so the hematoma can drain into the peritenon away from the stab incision in the skin (see Fig. 72–1*E*). The tendon knife is fanned within the core lesion, with care taken to avoid the splitting of adjacent normal tendon fibers. Large core lesions may require more than

[a]Gelpi retractor, Miltex Instrument Company, Inc., Bethpage, NY.

[b]DeBakey peripheral vascular clamp, Miltex Instrument Company, Inc., Bethpage, NY.

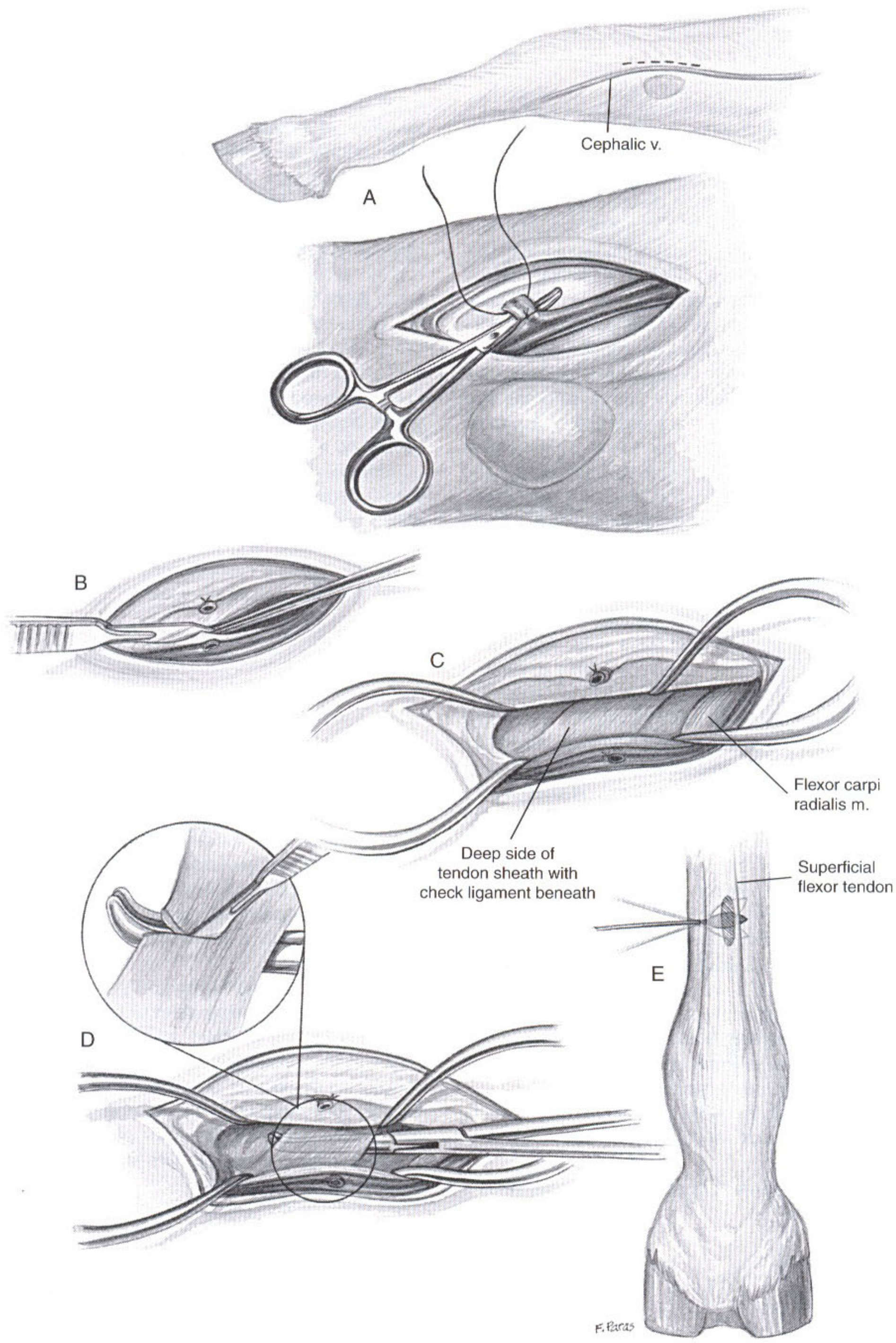
[c]PDS II, Ethicon, Inc., Somerville, NJ.

[d]Prolene, Ethicon, Inc., Somerville, NJ.

[e]Appose ULC, Davis & Geck, Inc., American Cyanamid Co., Manati, PR.

[f]Cottle double-edged knife, Baxter Healthcare Corp., Round Lake, IL.

Figure 72–1.


Cephalic v.
A
B
C
Flexor carpi radialis m.
Deep side of tendon sheath with check ligament beneath
D
E
Superficial flexor tendon
F. Paras

one stab incision. A single simple interrupted suture of size 2–0 polypropylene is placed in each stab incision, and the leg is protected with a sterile, padded bandage.

Postoperative Management

Proximal Check Desmotomy

Proper aftercare is essential for a favorable outcome. Because of the extensive dissection, the ligation of large vessels, the opening of the flexor carpi radialis tendon sheath, and the occasional opening of the carpal canal, seromas form in up to 30% of these cases. Stall confinement and maintenance of a firm pressure bandage for a minimum of 2 weeks help control this problem. If possible, the initial bandage applied during surgery is not disturbed for 3 to 5 days. Small seromas are allowed to resorb spontaneously. Large seromas that continue to increase in size are aseptically aspirated but not until at least 12 to 14 days after surgery. This delay allows the surrounding tissue to heal and for the seroma to be walled off in the event of secondary infection. The occasional persistent seroma may require the insertion of a Penrose drain.[8] In light of these postoperative management issues, we hospitalize the horse until the skin sutures have been removed and the wound is free of problems.[5] Phenylbutazone, 2.2 mg/kg per os b.i.d., is administered for 3 days. Antibiotics are administered to those cases requiring repeated drainage of a seroma. Tetanus immunization status should be current. Other complications, including wound dehiscence and infection, adversely affect the prognosis for future athletic soundness.

When proximal check desmotomy is used in the management of flexural limb deformities, splinting and corrective shoeing are usually used. Gutter splints of polyvinylchloride can be applied for up to 10 days when the horse is confined to a stall for healing. A shoe with an elevated heel selectively loads the superficial digital flexor tendon and is helpful for mildly or moderately affected cases. Gradually increasing exercise is initiated after the first 2 weeks. Some of these horses respond initially but regress when athletic work is started weeks or months later. Horses with severe or long-standing flexion deformities respond poorly to all forms of therapy, including surgery.[1]

Proximal check desmotomy has been reported to improve Thoroughbreds' and Standardbreds' return to racing after superficial digital flexor tendon injury.[2–5, 9] Ultrasonography is used to monitor the size of the core lesion and tendon healing throughout convalescence.[10] After the 2 weeks of postoperative stall confinement, hand walking is started for 6 weeks, and then light jogging or pasture exercise is allowed for 8 weeks.[5] If ultrasonography reveals improved echogenicity with longitudinal organization of the tendon fiber pattern, slow training is initiated. Complete healing with return to racing requires 10 months or more. In one report on Thoroughbreds, 36 of 51 horses that had been operated on were able to train or race.[3] Of the 36 horses, 32 made anywhere from 1 to 60 race starts, and 30 horses had no recurrence of tendinitis.[3] This is a significantly better response than what has followed traditional methods of therapy. However, one study documents equivocal results of surgical treatment, compared with nonsurgical treatment, of tendinitis in Thoroughbreds and alludes to an increased risk of suspensory desmitis after proximal check desmotomy.[11] An even higher percentage of Standardbreds return to racing and earn money without recurrence of the tendon injury. Eighty to 90% of Standardbreds operated on return to race at least once, and 70 to 85% complete five or more races.[4, 9] The results of proximal check desmotomy in other equine athletes with tendinitis, such as event horses, are disappointing compared with those of racehorses.[2]

Tendon Splitting

The aftercare for horses after tendon splitting is the same as for proximal check desmotomy (i.e., a pressure bandage and stall confinement for 10 to 14 days). Complications are rare. Tendon splitting results in a more rapid resolution of tendon core lesions as determined by ultrasonography.[2, 5, 6] The lesion size has been reported to decrease by up to 40% within 10 days after ultrasonographically guided tendon splitting.[5] This is associated with a decrease in tendon diameter and severity of injury.

Proximal check desmotomy and tendon splitting are useful in the management of horses with tendinitis. Careful selection of cases and meticulous attention to surgical and postoperative detail can be rewarding. It should be noted that convalescence is prolonged. Although it is frequently the reason for not operating, the cost of surgery is a minor part of the expense of rehabilitating a racehorse with superficial digital flexor tendinitis.

[8]Penrose tubing, Sherwood Davis & Geck, St. Louis, MO.

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chapter 73

Deep Digital Flexor Tenotomy

Deep digital flexor tenotomy is indicated for the treatment of severe flexural deformities of the distal interphalangeal joint and for management of refractory laminitis in which rotation or sinking of the third phalanx has occurred.[1–4] In foals with flexural deformity of the distal interphalangeal joint, tenotomy of the deep digital flexor tendon is indicated when inferior check ligament desmotomy has failed to correct the deformity. Athletic performance is not always possible after deep digital flexor tenotomy for flexural deformity, but many horses become sound for pleasure riding. Deep digital flexor tenotomy is indicated in horses with acute refractory laminitis when rotation or sinking of the third phalanx is rapid. Severing of the deep digital flexor tendon reduces the forces that separate the sensitive and insensitive laminae, leading to rotation of the third phalanx. Deep digital flexor tenotomy has also been used as an effective salvage procedure in horses with chronic refractory laminitis that has not been responsive to medical management and corrective shoeing.[4] The procedure reduces pain in the feet of these horses, but riding soundness is rarely achieved.[3]

Deep digital flexor tenotomy can be performed at the midmetacarpal area or the pastern area of the limb.[1] We believe the procedures are equally effective. We prefer tenotomy at the midmetacarpal area and describe it in this chapter. Tenotomy at the level of the pastern is described elsewhere.[4] Surgery at the midmetacarpal level is easy to perform, can be done in laminitic horses while they are standing, does not invade a tendon sheath, has little risk of contamination from septic laminitis or from the ground, and leaves some support to the distal interphalangeal joint from fascial attachments to the tendon distal to the tenotomy site.[5] Scar formation associated with marked cosmetic disfigurement has been reported with tenotomy at the midmetacarpal level.[2] We have not experienced this complication when horses are rested sufficiently after surgery and the operated limb is bandaged.

Before surgery, horses with laminitis should be shod with a heel extension to stabilize the foot and help prevent postoperative hyperextension or subluxation of the distal interphalangeal joint. Foals with flexural deformities need not be shod, but the hoofs should be trimmed to a normal conformation.

Anesthesia, Positioning, and Surgical Preparation

For tenotomy of the deep digital flexor tendon at the middle of the metacarpus, the hair is removed from the fetlock to the carpus and the skin is surgically prepared. In horses with laminitis, surgery can be performed with the horse in a standing position. The horse is sedated, and local anesthesia is achieved by infiltration of 8 to 10 ml of mepivacaine hydrochloride[a] or lidocaine hydrochloride[b] around the palmar nerves just proximal to the middle of the metacarpus. Both feet of horses with laminitis must be blocked with regional anesthesia in order to pick up the limb undergoing tenotomy. Standard draping is not done. However, a sterile adhesive barrier drape[c] may be placed around the metacarpus to decrease the risk of contamination. In foals and uncooperative adult horses, tenotomy can be performed after induction of short-acting intravenous anesthesia with the horse positioned in lateral recumbency with the affected limb uppermost. Routine surgical preparation and draping are recommended.

Surgery

A 2- to 3-cm skin incision is made directly over the lateral aspect of the deep digital flexor tendon in the middle of the metacarpus (Fig. 73–1*A*). No tendon sheath is present in this area. In the standing horse, the limb is picked up by an assistant to relax the deep digital flexor tendon. With curved Metzenbaum scissors for combined blunt and sharp dissection, the fascia between the deep digital flexor tendon, superficial digital flexor tendon, and suspensory ligament is separated. The deep digital flexor tendon is elevated from the incision using curved Kelly hemostats or scissors (Fig. 73–1*B*). After ensuring that the medial neurovascular bundle has been separated from the tendon, the operator transects the deep digital flexor tendon with a scalpel blade (Fig. 73–1*C*). The subcutaneous tissues are sutured with a simple continuous pattern using size 2–0 polydioxanone[d] suture material, and the skin is closed with the same pattern using size 1–0 polypropylene[e] suture material. Sterile bandages are applied over the surgical site. The hoofs of foals with flexural deformities should be trimmed to a normal conformation while the foals are still anesthetized.

An alternative method of tenotomy is to cut the deep digital flexor tendon blindly with a tendon bistoury while the animal is weight bearing.[3] Laceration of the medial vessels may occur with this technique.[3]

[a]Carbocaine V, Sterling Drug, Inc., McPherson, KS.
[b]Lidocaine hydrochloride, Phoenix Pharmaceutical, Inc., St. Joseph, MS.
[c]Ioban 2, Animal Care Products, 3M Health Care, St. Paul, MN.
[d]PDS II, Ethicon, Inc., Somerville, NJ.
[e]Prolene, Ethicon, Inc., Somerville, NJ.

Postoperative Management

Bandages should be maintained for a minimum of 30 days. Correction of flexural deformities of the distal interphalangeal joint may be immediate and is often associated with pain. The pain is due to stretching of the joint capsule, ligaments, and periarticular tissues around the joint.[2] Administration of nonsteroidal anti-inflammatory drugs is recommended. An acrylic cap may be applied over the dorsal hoof wall and toe of foals with a misshapen or damaged hoof wall caused by the flexural deformity. Heel extension shoes are not needed when deep digital tenotomy is used to treat flexural deformities. Foals should be confined to a large stall or small paddock and allowed unrestricted walking. Exercise can be gradually increased after 8 weeks, but total freedom should not be allowed for 6 months.[5]

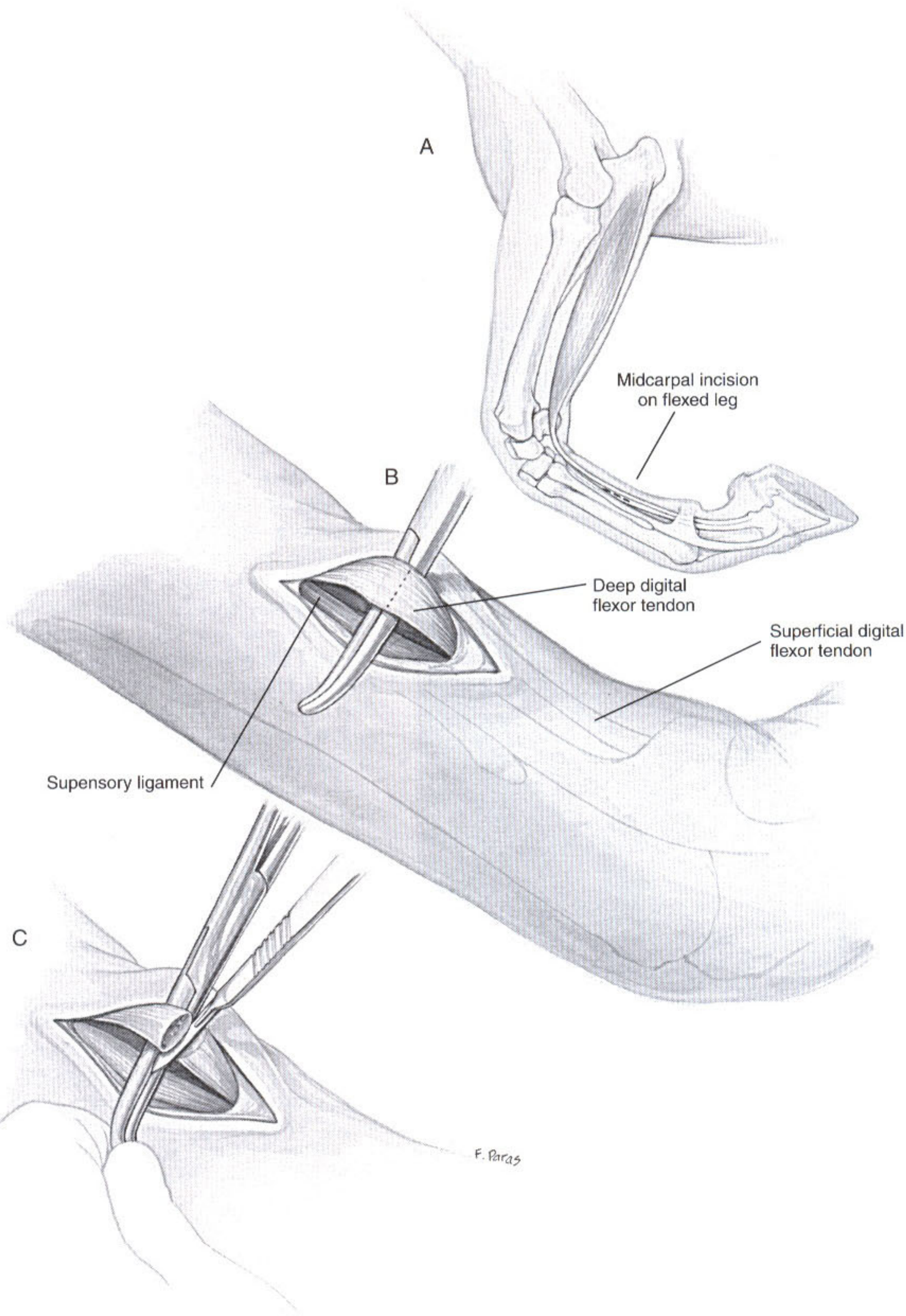
Horses with laminitis should be given nonsteroidal anti-inflammatory drugs as needed to control pain and be kept in corrective shoes. These horses should be rested for a minimum of 6 months. Medical treatments necessary for managing the laminitis should be continued as needed. Complications directly related to the surgery are uncommon but can include incisional infection, postoperative pain, digital hyperextension, and distal interphalangeal joint subluxation. Superficial digital flexor tendinitis may follow severance of the deep digital flexor tendon.[3, 5]

The prognosis for foals with flexural deformity of the distal interphalangeal joint is excellent for pasture soundness and fair for riding soundness when the deformity is corrected by surgery. Some horses may become athletically sound but for activities less strenuous than racing. Deep digital flexor tenotomy for laminitic horses is a salvage procedure.[4] In horses with acute refractory laminitis, the procedure will decrease pain but may not alter the survival rate.[3] Horses with chronic laminitis often have septic pedal osteitis and recurring laminar infections. These horses commonly experience secondary flexural deformities of the metacarpophalangeal joints from chronic pain. Repeat deep digital flexor tenotomy may be necessary and can be done in the pastern area to avoid the scar tissue from the first tenotomy in the midmetacarpal area.[4]

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Figure 73–1.


A
Midcarpal incision
on flexed leg
B
Deep digital
flexor tendon
Superficial digital
flexor tendon
Supensory ligament
C
F. Paras

chapter 74

Surgical Treatment of Angular Limb Deformities

Angular limb deformities occur predominantly in young foals. They are characterized by lateral or medial deviation of a limb from a normal straight axis. Most foals also have a small amount of rotational deviation. The most common angular limb deformity in foals is carpal valgus (Fig. 74–1). Varus deformity of the fetlock, valgus deformity of the tarsus, and varus deformity of the carpus occur less frequently. Perinatal factors and developmental factors are assumed to be responsible for angular limb deformities.[1] Diagnosis is made by observation of the deformity. Evaluation of foals with angular limb deformities should include manipulation to determine whether the limb can be manually straightened and radiography to determine the maturity and condition of the tarsal and carpal cuboidal bones and to assess abnormalities of long bones.

Nonsurgical methods for treatment of angular limb deformities include stall rest, application of splints or tube casts, and corrective hoof trimming. Many newborn foals with angular limb deformities respond to stall rest. Newborn foals with incomplete ossification of the cuboidal bones or flaccidity of periarticular structures have limbs that can be manually straightened and will benefit from splints or tube casts. A more thorough discussion of nonsurgical treatment methods can be found in other sources.[1–3]

Surgery is necessary for correction of angular limb deformities in some foals. Surgery is indicated in neonatal foals with angular limb deformities of the carpus and tarsus that cannot be straightened manually and do not improve with 2 to 3 weeks of stall rest, foals with developmental angular limb deformities of the carpus or tarsus that do not respond to rest and nutritional changes, and all neonatal foals with angular limb deformities of the fetlock. The most common surgical methods to promote straightening of the limbs are periosteal transection and transphyseal bridging. Both methods cause unequal growth across the physis to straighten the limb; hence, both methods require that the physis be active. Periosteal transection is the primary surgical technique used for correction of angular limb deformities. This technique has gained wide acceptance since first being described for foals by Auer et al.[4]



Figure 74–1.
Marked carpal valgus deformity in a foal. This deformity responded to a combination of periosteal stripping on the lateral aspect and transphyseal bridging on the medial aspect of the left forelimb.

Periosteum forms a fibroelastic sheath, which inhibits long bone growth. Periosteal transection releases the sheath and accelerates growth of the physis on the released side. As this side lengthens, the limb straightens. Periosteal transection is a straightforward procedure that requires no special tools; does not require implants, which subsequently have to be removed; does

not result in overcorrection; may be repeated for additional straightening in some circumstances; is cosmetic; and is less expensive than transphyseal bridging. Transphyseal bridging restricts growth of the physis and is performed on the convex side of the deformity. The most common method for restricting growth is the placement of screws on each side of the physis, which are then connected by figure-of-eight wires. This creates pressure across one side of the physis, retarding endochondral ossification and slowing long bone growth at the metaphysis. The screws and wires must be removed once the limb is straight or overcorrection may occur.

Indications for transphyseal bridging include correction of severe (>25°) angular limb deformities of the carpus or tarsus in young foals and correction of significant angular limb deformities in older foals for which the rapid growth of the associated long bone is over. However, some growth potential must be left in order for surgery to be successful. Transphyseal bridging is often performed in combination with periosteal transection to achieve growth acceleration on one side and retardation on the other side of the same physis. Combined techniques can hasten correction of angular limb deformities. To ensure that physes are actively growing, thus making correction of angular limb deformities possible, surgery should be performed on foals with fetlock deformities by 2 months of age, on foals with tarsal deformities by 4 months of age, and on foals with carpal deformities by 6 months of age.[1] The reader is advised to consult surgical textbooks for more information on the selection of foals for surgical treatment.[1–3]

Periosteal Transection

Anesthesia, Positioning, and Surgical Preparation

Periosteal transection is most commonly performed on the lateral aspect of the distal radius for treatment of valgus deformity of the carpus. General anesthesia is required, and experienced surgeons may elect to use a short-acting intravenous anesthetic for the procedure, which can take as little as 5 minutes per site in young foals. Foals are most often positioned in lateral recumbency with the affected limb uppermost to gain access to the lateral (concave) side of the limb. The foal can be rolled over when bilateral valgus deformities are present to expose the lateral aspect of the opposite limb. Alternatively, the foal can be positioned in dorsal recumbency with the limbs tied overhead in extension. The hair should be removed from the carpometacarpal region to above the middle of the radius around the entire circumference of the limb, and routine skin preparation is performed. A hooked scalpel blade[a] is used for periosteal transection. A small rongeur[b] and a small periosteal elevator[c] are useful for performing periosteal transection on foals older than 1 month.

Surgery

Carpal Valgus. After the surgery site is draped, a straight longitudinal 4-cm-long skin incision is made between the tendons of the common and lateral digital extensors on the lateralmost aspect of the radius. The incision extends proximally from a point just proximal to the physis and is carried through the subcutaneous tissues down to the periosteum (Fig. 74–2*A*).

The physis is located at the widest part of the radius. If the surgeon is unsure of its location, a 20-gauge needle can be used as a probe to locate the physis. A curved hemostat forceps is used to dissect bluntly against the periosteum cranially and caudally for nearly one half the circumference of the radius at a level 1 to 2 cm above the physis. This maneuver separates the subcutaneous tissues and the tendons of the common and lateral digital extensor muscles from the periosteum. On the caudal aspect of the radius, blunt dissection will expose the rudimentary ulna. Dissection should follow a plane between the rudimentary ulna and the tendons. The tips of the curved forceps are inserted cranially along the periosteum, opened slightly, and used as a lever to retract the subcutaneous tissues and tendons away from the periosteum of the radius. The hooked scalpel blade is inserted cranially under the hemostat, and, with moderate pressure, the periosteum is transected parallel to the physis from the cranial aspect of the radius to the lateral aspect. The same procedure is repeated on the caudal side of the radius so that the two periosteal incisions connect on the lateral aspect of the radius (Fig. 74–2*B*). In young foals, the rudimentary ulna is transected with the periosteum using the scalpel blade. In older foals or foals with an ossified ulna, a rongeur is used to severe the ulna (Fig. 74–2*C*).

Next, the periosteum is incised parallel to the skin incision starting at the horizontal incision and proceeding proximally 2 to 3 cm, creating a T-shaped incision. Ligation or electrocoagulation is infrequently necessary to control hemorrhage. The two triangle-shaped periosteal flaps are elevated from the metaphysis of the radius with the periosteal elevator or a scalpel handle in young foals (Fig. 74–2*D*). The flaps are left in situ against the radius once they are elevated. The subcutaneous tissues

[a]No. 12 Bard-Parker surgical blade, Becton Dickinson AcuteCare Division, Franklin Lakes, NJ.

[b]Bone rongeur, Miltex Instrument Company, Inc., Bethpage, NY.

[c]Freer periosteal elevator, Miltex Instrument Company, Inc., Bethpage, NY.

Figure 74–2.

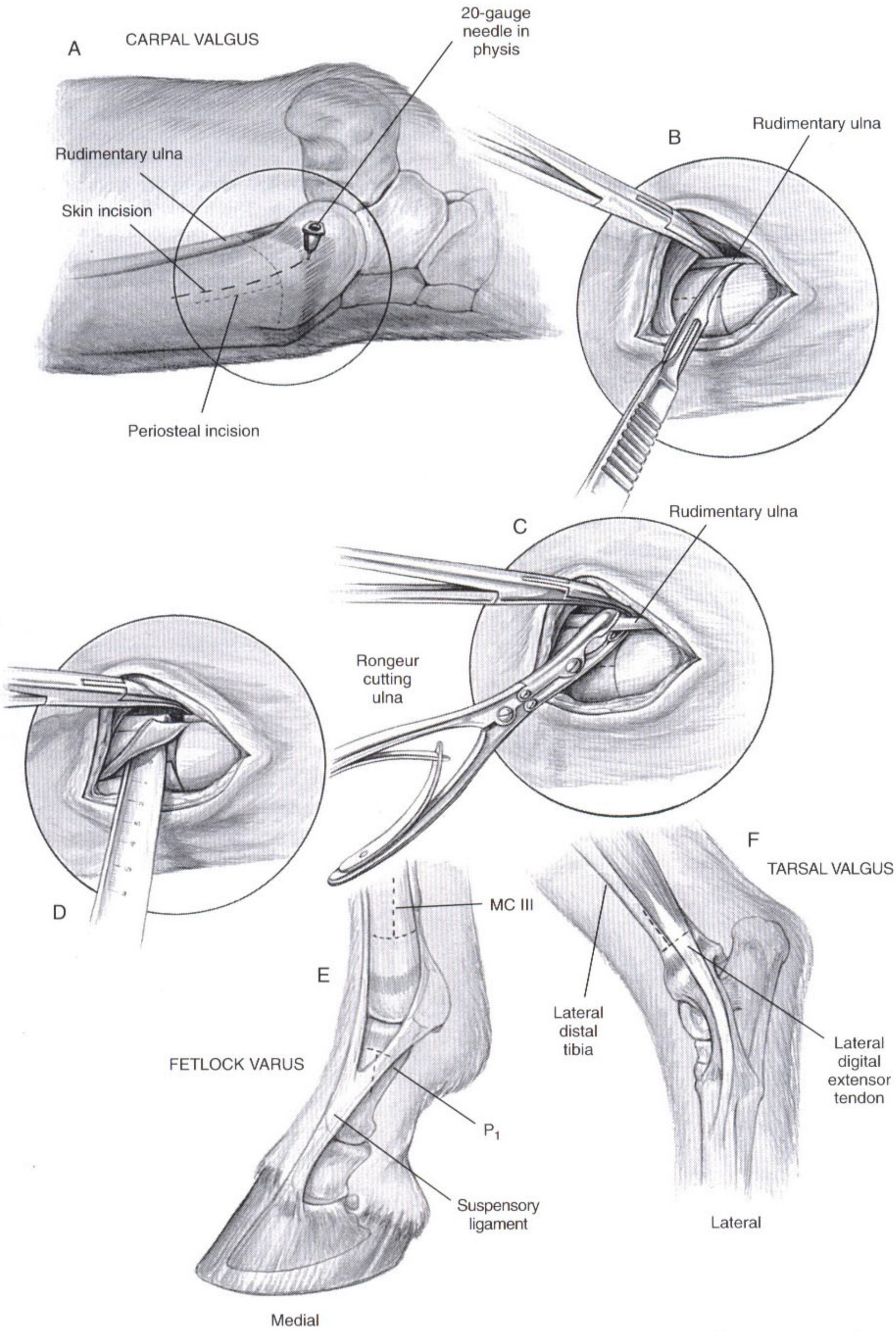


Illustration continued on page 369

are closed with size 2–0 polydioxanone[d] suture material in a simple continuous pattern. A simple continuous intradermal suture line is placed to close the skin. Skin sutures are acceptable instead of intradermal sutures, but they must be removed in 7 to 10 days.

Fetlock Varus. Periosteal transection can be used for correction of angular limb deformities of the fetlock. The most common deformity is fetlock varus. Periosteal transection is performed on the convex (medial) side of the limb at the distal aspect of the third metacarpal or metatarsal bone and at the proximal first phalanx. Surgery on the first phalanx is done at the level where the extensor branch of the suspensory ligament passes over the medial aspect of the bone. This is approximately 2 cm below the joint space (Fig. 74–2*E*). The transverse periosteal incision of the metacarpal-metatarsal bone should be made just below the distal end of the splint bone and should avoid the fetlock joint capsule.

Tarsal Valgus. Valgus deformity of the tarsus is treated by periosteal transection on the lateral side of the distal tibia. Because the lateral digital extensor tendon lies directly over the lateralmost aspect of the tibia, the skin incision is made cranial or caudal to this tendon. The transverse hemicircumferential incision of the periosteum goes beneath the tendon about 1 cm proximal to the physis (Fig. 74–2*F*).

[d]PDS II, Ethicon, Inc., Somerville, NJ.

Postoperative Care

A bandage placed directly over the surgery site is applied using several sterile 4 × 4-inch gauze sponges held in place with a sterile soft gauze bandage and covered with an elastic adhesive bandage.[e] This bandage can be changed every 3 or 4 days, with the limb remaining bandaged for up to 10 days. Foals should be confined to a large stall for 3 weeks. Strenuous exercise should not be allowed until the angular limb deformities are corrected. The hoofs should be rasped so they are balanced and level. Excessive trimming on the outside of the hoofs in foals with carpal valgus may create a secondary fetlock varus and should be avoided. Tetanus prophylaxis should be ensured. The foal should be placed on a proper diet and any nutritional imbalances corrected.

Complications are uncommon. Transection can be repeated in 2 months if additional correction is required and the physis is still growing. The prognosis for correction of valgus deformities of the carpus is good when surgery is performed before the rapid growth period is over. It has been reported that Thoroughbred racehorses undergoing periosteal transection for angular limb deformities are slightly less likely to race than horses not requiring surgery, but earnings per start are not significantly different.[5]

[e]Elastikon, Johnson and Johnson, New Brunswick, NJ.

Transphyseal Bridging with Screws and Wires

Anesthesia, Positioning, and Surgical Preparation

Perioperative antibiotics are administered. Growth retardation using screws and wires to bridge the physis requires general anesthesia. We prefer inhalation anesthesia because operative time can be variable when multiple angular limb deformities are being treated. Screws and wires are placed on the convex side of the deviated limb. In foals with valgus deformity of the carpus, the hardware is placed medially. Foals are usually positioned in lateral recumbency with the operative side uppermost, but they may be positioned in dorsal recumbency if two limbs require surgery or if transphyseal bridging and periosteal transection are performed concurrently. Hair is removed, and routine surgical preparation of the skin is performed. Meticulous asepsis, including proper draping, is required because implants are used. When transphyseal bridging is combined with periosteal transection, the bridging is done first.

Instrumentation

Screws must be placed on each side of the physis. Suitable screws for transphyseal bridging of the distal radius include 4.5-mm cortical screws, 5.5-mm cortical screws, and 6.5-mm cancellous screws.[f] Screws should be 32 to 40 mm in length and fully threaded. The instrumentation for insertion of these screws includes a drill, appropriately sized drill bits, drill guides, depth gauge, tap, tap sleeve, and screwdriver. Alternatively, self-tapping, fully threaded screws[g, h] may be used. Insertion of self-tapping screws requires only a drill, drill bit, and screw driver. Stainless steel 18-gauge wire,[i] a wire twister,[j] and wire cutters are needed to place the figure-of-eight wire around the screws. Sterilized pliers may be used in lieu of a wire twister. Intraoperative radiographs should be taken by all but the most experienced surgeons to ensure correct placement of the screws. This requires a portable radiography machine or fluoroscope and sterile cassette covers.[k] Alternatively, cassettes can be wrapped in a sterile drape before being positioned in the surgical field.

[f]ASIF instruments and implants, Synthes (USA), Paoli, PA.

[g]ASIF 4.5-mm titanium cortex screws, self-tapping, Synthes (USA), Paoli, PA.

[h]4.5-mm cortical bone screws, self-tapping, Smith & Nephew Richards Inc., Memphis, TN.

[i]Orthopedic wire, IMEX Veterinary, Inc., Longview, TX.

[j]Wire twister, Miltex Instrument Company, Inc., Bethpage, NY.

[k]Cassette covers, General Econopak, Philadelphia, PA.

Surgery

For correction of carpal valgus deformities, an 8- to 10-cm slightly curved skin incision is made over the medial aspect of the radius, with the convex side facing caudally. The distal end of the incision is at the level of the antebrachial carpal joint. The medial aspect of the radius is exposed, and the physis is identified by probing the most prominent aspect of the radius with a 20-gauge, 1½-inch needle (Fig. 74–2*G*). A second needle can be inserted into the antebrachial carpal joint to identify the limits of the medial aspect of the epiphysis of the radius. Intraoperative radiographs can be made if the surgeon is unsure of needle placement.

The first screw is placed in the medial epiphysis halfway between the joint and the physis. To place the screw, a stab incision with the scalpel blade is made in the collateral ligament extending down to the bone. The appropriate-sized drill bit for the selected screw is used to drill a hole to a depth of 40 mm. The drill bit should remain centered in the epiphysis and be parallel to the physis. Intraoperative imaging to ensure proper placement of the epiphyseal screw is recommended. When positioning is correct, the screw is inserted but not tightened to the point at which the head disappears into the collateral ligament. The second screw, which is the same size as the first screw, is placed 3 to 4 cm above the physis in the metaphysis of the radius (Fig. 74–2*H*). The exact location is not as critical as the location of the epiphyseal screw, but the screw should be positioned so that its head and the figure-of-eight wires around it are not directly under the skin incision. This decreases the risk of infection around the implants.[5] The screw is not tightened completely, leaving the head exposed sufficiently to loop the wire around the shaft of the screw just beneath the head. Countersinking is not done for either screw.

Two independent figure-of-eight wires connect the screws. Each wire is separately placed and tightened around the screws by twisting the ends together (Fig. 74–2*I*). We recommend using a wire twister to produce a symmetric, even twist. The twisted wires are cut so the ends are 5 mm long, and the ends are bent so they point distally and lie snugly against the soft tissues over the bone. No sharp ends of wire, which may penetrate the skin postoperatively, should protrude from the bone. The screws are tightened until the heads are level with the soft tissues. Tightening the screws causes additional tension in the wires as the loops of wire slide up the tapered head of the screws (Fig. 74–2*J*). Care should be taken not to overtighten the screws, or the wires may slip off the heads. Intraoperative imaging may be done to check for correct placement of the implants. The subcutaneous tissues are closed with a simple continuous suture pattern using size 2–0 polydioxanone suture material. The skin is closed with an intradermal suture pattern using the same material or with a simple continuous suture pattern using a monofilament nonabsorbable suture material.

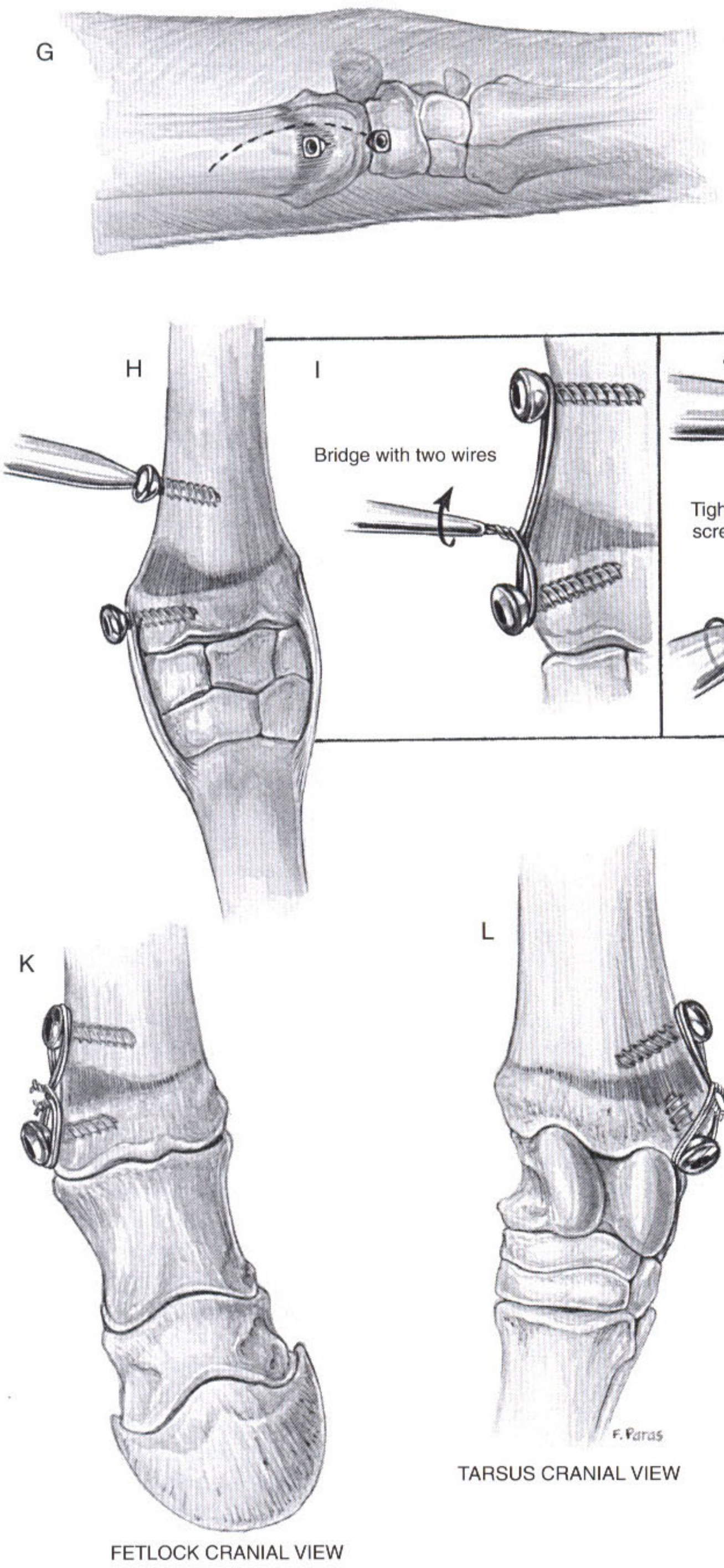
Fetlock Varus. Growth retardation with screws and wires is recommended in addition to periosteal transection to correct moderate to severe fetlock angular limb deformities, particularly in foals older than 2 months. A curved incision over the lateral aspect of the distal metacarpus or metatarsus is made dorsal to the palmar-plantar vessels. Implants bridging the distal physis are positioned in the lateralmost aspect of the bone (Fig. 74–2*K*). The implants should not lie directly under the skin incision. The implants are inserted with a technique similar to that described for the carpus. Intraoperative imaging should confirm the correct position of the screws before skin closures.

Tarsal Valgus. Screw and wire insertion to bridge the medial aspect of the distal tibial physis for correction of tarsal valgus is a demanding surgery because of the irregular distal tibial physis and the close proximity of the tarsocrural joint.[1] The epiphyseal screw must be angled from a distal to proximal direction to avoid damaging the medial trochlea of the talus (Fig. 74–2*L*). Intraoperative imaging to ensure correct screw placement is essential.

Postoperative Care and Removal of Implants

Postoperative care after transphyseal bridging is the same as that after periosteal transection, with one important difference. The screws and wires must be removed when the limb is straight, or overcorrection may occur. Owners must be clearly informed that once the limbs are straight the implants must be removed. We recommend removal of the implants when the owners are satisfied with the conformation of the limbs. With bilateral angular deformities, the implants may have to be removed at separate times to achieve proper correction in each limb. The implants can be removed from the distal radius in cooperative foals in a standing position after sedation and instillation of local anesthetic over the heads of the screws and above the cerclage wires. Unmanageable or nervous foals should be anesthetized. A stab incision is made directly over the head of the proximal screw, which is usually easily palpated with a finger. A mosquito hemostat forceps is used to spread the subcutaneous tissue and scar tissue over the screw, and the screwdriver is firmly seated in the head. Inadequate seating of the screwdriver may strip the head of the screw, making removal difficult. Similarly, the screw in the epiphysis is removed. The epiphyseal screw is often covered with more scar tissue and is more difficult to identify. An 18-gauge needle can be used to probe for the metallic head of the screw when it is not readily found. After the screws are removed, a

Figure 74–2. *Continued*



heavy curved hemostatic forceps is used to hook the proximal loops of the figure-of-eight wires and pull them out of the proximal stab incision. This usually requires some amount of force. Wires should be pulled proximally because the twisted ends of the cerclage wires had been turned distally during insertion. An assistant may be necessary to stabilize the foal's limb while the cerclage wires are removed. The stab incisions are closed with simple interrupted sutures, and the sites are covered with a light bandage for 7 to 10 days, at which time skin sutures can be removed.

Serious complications are not common. Infection around the implants may necessitate early removal. Failure to remove implants in a timely manner may result in overcorrection. Swelling and scar tissue buildup around the implants is frequent but usually resolves after the implants are removed and the foal matures.

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chapter 75

Surgical Treatment of Bone Spavin

Tarsal disease is the most common cause of chronic hindlimb lameness in performance horses. It presents in different ways in different breeds, causing definitive lameness, obscure lumbar pain, reduced performance, or a combination of all three. Racing Thoroughbreds with bone spavin are affected at a relatively early age, and radiographs may be helpful in establishing the diagnosis.[1] Standardbreds are affected with a cunean bursitis-tarsitis soft tissue syndrome, often without diagnostic radiographic changes.[2] Nonracing athletes that sustain continuous, repetitive, slow movements on a soft surface may present with a "cold back" and have no signs referable to the tarsal disease, which is the primary reason the horse has guarded its movements with its back muscles. The variation in signs among individual horses, among breeds, and among athletic activities has created confusion about the diagnosis of tarsal disease and the different techniques for confirming the diagnosis and controversy about treatment.[1–3]

Bone spavin is osteoarthritis of the distal intertarsal and tarsometatarsal joints. Tarsal osteoarthritis is a "wear-and-tear" disease of mature working horses and is commonly associated with poor conformation, repetitive trauma from exercise, certain shoeing practices, or hard training. Young horses with developmental orthopedic disease (osteochondrosis) can develop juvenile spavin, which is clinically indistinguishable from that of traumatic origin.[4] Some of these younger horses develop signs after the trauma of training and performance has started, adding further to the controversy about the pathogenesis of this syndrome. Typically, bone spavin is a bilateral disease. The natural endpoint of osteoarthritis in the intertarsal and tarsometatarsal joints is spontaneous fusion. Although this often alleviates the pain and lameness, spontaneous fusion is slow and may be incomplete.

Treatments that alleviate the pain or hasten joint fusion help to maintain the performance status of horses affected by tarsal disease. A large number of treatments have been recommended for tarsal disease, including corrective shoeing, rest, analgesics and controlled exercise, systemic administration of polysulfated glycosaminoglycans or hyaluronic acid, counterirritation (firing and blistering), intra-articular medication, and surgery. An overall success rate of about 50% has been achieved. Surgical treatments have been tried, modified, abandoned, and reinstituted over the years, adding to the controversy and establishing that a consistently reliable treatment is not presently available. Two surgical treatments, cunean tenectomy and arthrodesis of the distal tarsal joints, are frequently used by practicing veterinarians in the management of tarsal disease and may be successful when patient selection is correct.

Cunean Tenectomy

Cunean tenectomy is the removal of a segment of the medial tendon of insertion of the tibialis cranialis muscle as it crosses the medial aspect of the hock. The cunean bursa is obliterated, and the region is somewhat denervated by the procedure. Cunean tenectomy has been acclaimed and condemned over the years.[1] It has been used as an initial therapy for bone spavin and as a last resort. Seemingly, it would be the ideal treatment for simple cunean bursitis that is confirmed by the intrabursal injection of a local anesthetic followed by suitable clinical improvement. Unfortunately, cunean bursitis is usually accompanied by a generalized tarsitis-capsulitis, particularly in Standardbreds, that precludes a reliable response to cunean tenectomy alone.[2, 5] We perform a cunean tenectomy in cases of simple cunean bursitis, as a first step in performing surgical arthrodesis, or when it is requested by owners or referring veterinarians in cases for which there are no contraindications.

Anesthesia, Positioning, and Surgical Preparation

Cunean tenectomy is performed on the standing horse using chemical restraint and local anesthesia. Because the problem is usually bilateral, both hocks are

operated on at the same time. Xylazine hydrochloride[a] combined with butorphanol tartrate[b] or detomidine hydrochloride[c] alone tranquilizes the horse, reducing the tendency to shift weight from leg to leg. High dosages of these drugs, which cause swaying or unsteadiness, should be avoided. The tail is bandaged to a short length or tied out of the field of surgery to avoid intraoperative contamination. The entire circumference of the hock is clipped from the midcannon to the midgaskin and routinely scrubbed for aseptic surgery. Although the incision site is limited to the medial surface of the hock, a liberally prepared field allows the sterile, gloved hands of the surgeon greater latitude for instrumentation when working between the hind limbs of the standing horse. Twelve to 15 ml of 2% mepivacaine hydrochloride[d] is injected subcutaneously along the incision line directly over the cunean tendon and into the cunean bursa beneath the tendon. The bursa should noticeably distend. Twitch restraint may be desirable at the time of local anesthetic infiltration and skin incision. A final surgical scrub is applied after anesthetic infiltration. No draping is necessary, but a self-adhering impervious drape wrapped around the tarsus provides a sterile barrier. The surgeon should perform a routine surgical scrub, don sterile surgical gloves, and use autoclaved instruments. Perioperative antibiotics are unnecessary.

Surgery

A 4- to 5-cm oblique incision is made through the skin and subcutaneous tissue directly over the cunean tendon on the medial aspect of the hock (Fig. 75–1*A*). The landmarks are the tendon of insertion of the tibialis cranialis muscle on the dorsum of the hock and the distal aspect of the chestnut (see Fig. 75–1*A*). Unless there has been previous scarring, the tendon can be palpated in most horses. A vertical incision can be used and is routine if cunean tenectomy is combined with surgical arthrodesis. With the tendon exposed, a curved Kelly or Crile forceps is forced into the cunean bursa under the tendon. Care must be taken to elevate the full width of the cunean tendon, which may be wider than 2 cm (Fig. 75–1*B*). The surgeon should excise 3 to 4 cm of tendon. The tendon is excised over the underlying forceps, and the free ends are grasped, peeled from the surrounding fascia, and cut free (Fig. 75–1*C*). Metzenbaum scissors can be used to sharply dissect the margins of the tendon from surrounding fascia, aiding the excision of a liberal segment. The deeper tissues are left undisturbed. We do not practice the Wamberg modification.[3,5] Suturing is confined to the skin. Simple interrupted sutures of a size 2–0 monofilament synthetic material suffice.

Postoperative Management

A dry, sterile dressing is bandaged in place over the incision with elastic tape.[e] Horses that tend to develop distal limb edema are provided with support bandages. The bandages are reset as needed and maintained for 2 to 3 weeks. The need for nonsteroidal anti-inflammatory therapy is based on the underlying disease and the intended postoperative exercise schedule. The tetanus immunization status should be current. Practices vary regarding the return of horses to exercise. Some veterinarians recommend that horses be continued in training right after surgery, believing that the initial analgesia from the local anesthetic and surgery is helpful. We prefer to rest the patient for 12 to 14 days and have the sutures removed before forced exercise is resumed. Corrective shoeing is a frequent consideration when these horses are returned to performance.

Complications of cunean tenectomy are infrequent. Wound infection and dehiscence are best managed by subsequent open wound healing. Depending on the nature of the underlying tarsal disease, many horses remain lame after cunean tenectomy. There has never been a large retrospective study of the results of cunean tenectomy, but one survey established a high level of owner satisfaction.[5] As stated earlier, there are proponents of the surgery and those that doubt whether the operation is worth the expense.[6] There is little doubt that scar tissue tends to re-establish the cunean tendon. On palpation, this scar tissue feels like the original tendon.

Arthrodesis of the Distal Tarsal Joints

The rationale for surgical arthrodesis of the distal intertarsal and tarsometatarsal joints, by the drilling out of articular cartilage, is to hasten the spontaneous ankylosis associated with bone spavin. The complete loss of these low-motion joints has no effect on the performance status of horses, making them ideal joints for deliberate surgical ablation. When surgical arthrodesis was first introduced, an aggressive approach to ablating the articular cartilage of the involved joints was advocated in the belief that most or all of the articular cartilage needed to be removed for the ankylosis to proceed uneventfully.[7] When the procedure was performed aggressively, there was extensive postoperative pain and prolonged convalescence, often lasting as long

[a]Rompun, Miles Inc., Shawnee Mission, KS.
[b]Torbugesic, Fort Dodge Laboratories, Inc., Fort Dodge, IA.
[c]Dormosedan, Pfizer Inc., New York, NY.
[d]Carbocaine V, Sterling Drug, Inc., McPherson, KS.
[e]Elastikon, Johnson & Johnson Medical Inc., Arlington, TX.

Figure 75–1.

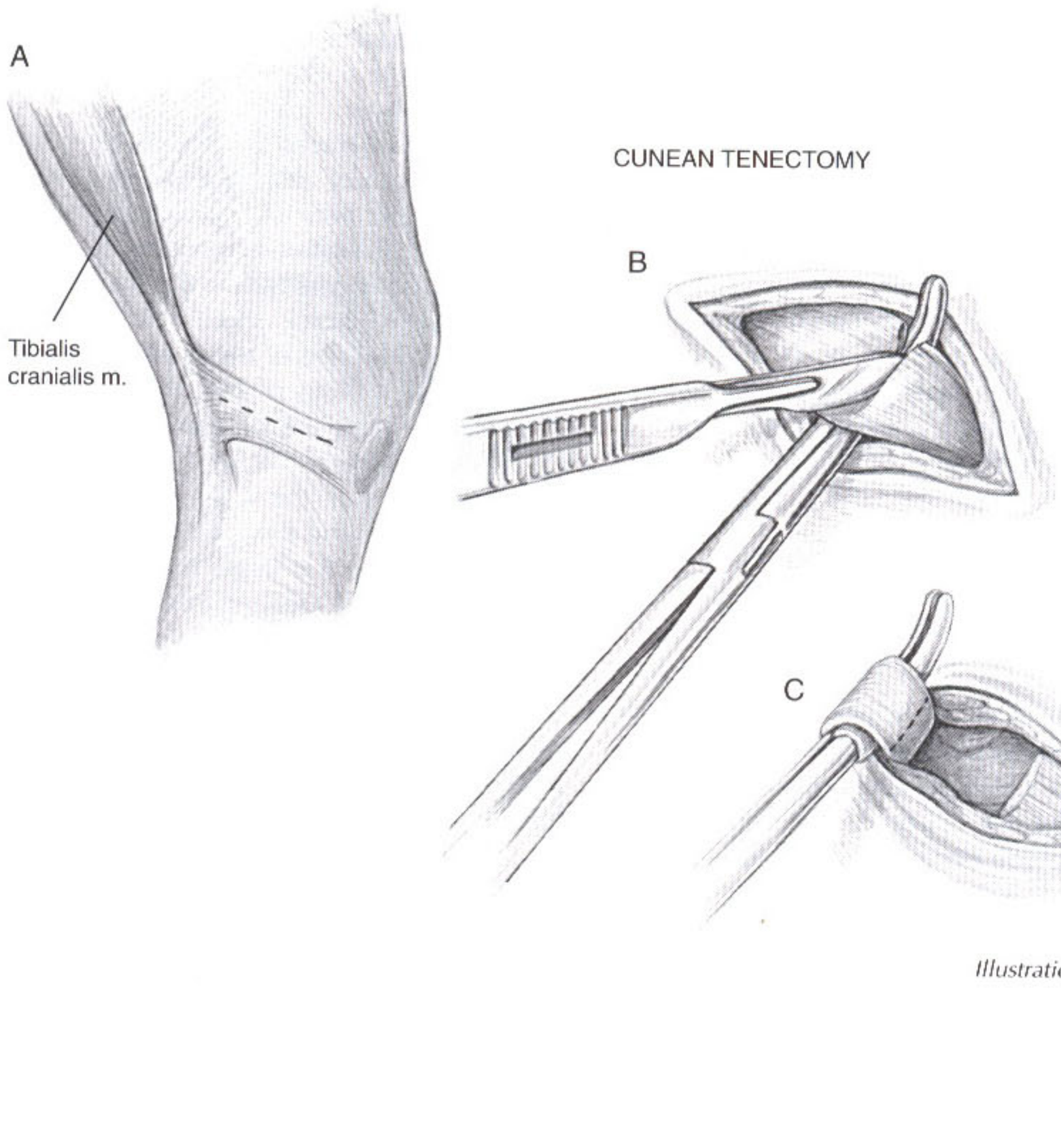


Illustration continued on page 375

as the spontaneous disease. Other investigators, evaluating similar methods of arthrodesis, encountered complications such as tarsal instability and tarsal bone fracture in addition to the significant postoperative pain and protracted convalescent periods.[8] A less aggressive approach to articular cartilage removal has been reportedly successful in limited numbers of cases.[3, 9–11] This approach merits consideration and can be recommended when osteoarthritis causes the lameness and when intra-articular medical therapy has failed.[1, 6, 12]

Two other surgical methods for treating osteoarthritis of the distal intertarsal and tarsometatarsal joints have been described. Sodium monoiodoacetate has been experimentally evaluated for treatment of bone spavin.[13] This substance destroys articular cartilage when injected into joints. Treated joints show radiographic and histologic evidence of fusion, but the drug has not been approved for use in horses, and the widespread adoption of this approach is premature.[14] The second technique is performed by drilling a communication between the subchondral medullary bone and the articular surfaces of the tarsal bones. This procedure resulted in a 62% cure rate of bone spavin in one study of 40 horses.[15] The technique may work by reducing subchondral bone pressure. The approach is technically simple, can be used in addition to other medical or surgical treatments, and is based on a sound theory. Unfortunately, there has been a single report and no evidence of its widespread use.

Anesthesia, Positioning, and Surgical Preparation

Surgical arthrodesis of the distal tarsal joints requires general anesthesia and aseptic technique. The horse is positioned in lateral recumbency with the affected limb down and the opposite hind limb pulled out of the field to provide access to the medial aspect of the affected hock. If both hocks are to be operated on, the horse can be rolled over or positioned in dorsal recumbency. We prefer dorsal recumbency to avoid repositioning the patient during surgery. Intraoperative radiography is used to ensure proper placement of the drills. The hock is clipped and surgically scrubbed as has been described for cunean tenectomy. Self-adhering, antiseptic impregnated impervious drapes[f] are recommended. Perioperative antibiotics are used routinely. Because implants are not used, we use penicillin alone. A sharp, preferably new, 3.2- or 4.5-mm drill bit, a drill guide, and a hand drill[g] are the special equipment required for this procedure. Suction and cautery are helpful.

[f]Ioban 2, Animal Care Products, 3M Health Care, St. Paul, MN.
[g]Hand drill, Zimmer, Inc., Warsaw, IN.

Surgery

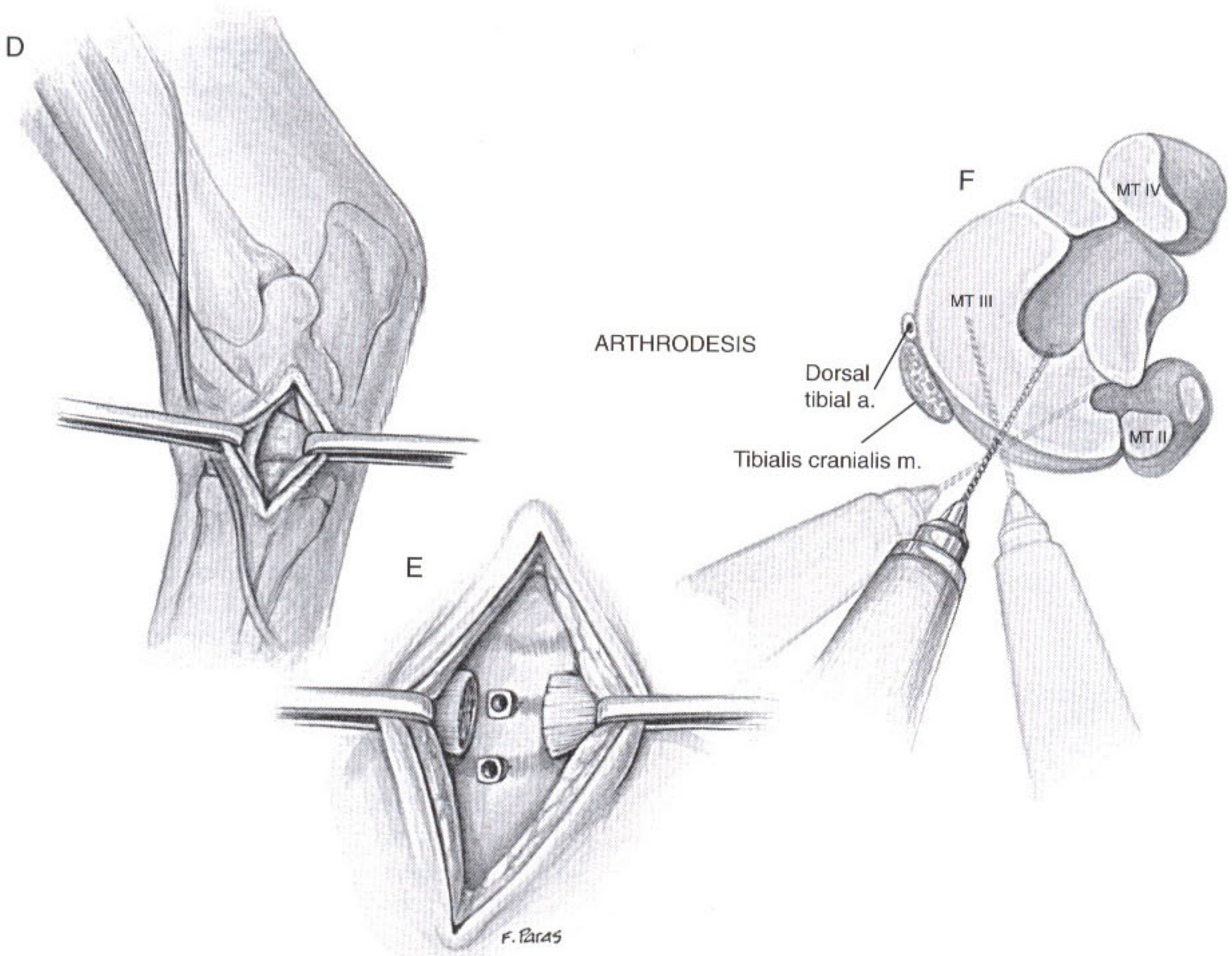
A cunean tenectomy is the first step in performing tarsal arthrodesis. A 5-cm vertical skin incision, centered over the medial aspect of the distal row of tarsal bones, is made midway between the saphenous vein and an imaginary line that marks the junction of the second and third metatarsal bones. The vertical incision provides easier access to the distal intertarsal and tarsometatarsal joints than the oblique incision used for cunean tenectomy alone (Fig 75–1*D*). After tenectomy, both tarsal joints are probed with 22-gauge, 1.5-inch needles to locate the drill sites (Fig. 75–1*E*).[3, 6, 9] Osteophytes associated with the osteoarthritis can interfere with locating the joints. Drill entry sites should be centered over the medial aspect of the joints (see Fig 75–1*E*). Radiographs are used to establish the location and direction of the needles to ensure drilling the joints in the correct plane.

Three drill tracks up to 3 cm deep are made from a single drill entry along the plane of both joints. The drill tracks are dorsolateral, lateral, and plantolateral (Fig. 75–1*F*). No effort is made to "fan" the drill bit in a reaming fashion between the tracks. Overdrilling of the dorsolateral track should be avoided to prevent inadvertent puncture of the dorsal tibial artery (see Fig. 75–1*F*). Overdrilling of the plantarolateral track risks entry of the tarsal flexor canal. The 3.2-mm drill bit follows the plane of the joint more readily but is more easily broken than the 4.5-mm bit. The surgeon must gain experience and then decide on the best bit size in his or her hands. Bits larger than 4.5 mm should never be used for fear of creating joint instability. A hand drill reduces the chance of creating too much heat and bone necrosis. The flutes of the bit should be cleaned frequently to aid drilling, but chips of cartilage and subchondral bone are left in the drill tracks without adverse effects. Because of its communication with the tibiotarsal joint, the proximal intertarsal joint should not be subjected to surgical arthrodesis. Osteoarthritis of this major joint is a significant threat to athletic usefulness.

The incision site is irrigated and suctioned to remove bony debris. A layered closure is used to suture the wound. The subcutaneous tissues are sutured with a size 2–0 monofilament synthetic delayed-absorbable material[h] in a simple continuous pattern. The skin is closed either with a simple interrupted dermal-epidermal pattern using size 3–0 delayed-absorbable material in the dermal layer and 2–0 polypropylene[i] in the epidermal layer or with vertical mattress sutures of polypropylene. Careful dermal-epidermal apposition is fundamental to early epithelial bridging of the incision and the avoidance of wound infection.

[h]PDS II, Ethicon, Inc., Somerville, NJ.
[i]Prolene, Ethicon, Inc., Somerville, NJ.

Figure 75–1. *Continued*



Postoperative Management

The hock is bandaged as described for cunean tenectomy, including a support bandage of the distal limb. Bandaging and stall rest are maintained for 2 to 3 weeks. Nonsteroidal anti-inflammatory therapy is routine for these cases, but this modified arthrodesis procedure is associated with minimal pain compared with the earlier, aggressive techniques. Perioperative antibiotics are not continued beyond the first 24 hours. Hand walking is initiated at 12 to 14 days, after the skin sutures are removed. Pasture exercise is allowed or performance training is reinitiated on an individual basis, depending on the duration of postoperative pain and lameness. Continued activity on the operated limb is believed to hasten ankylosis. If there has been attention to detail, complications are rare.

Clinical impressions of this technique have been favorable, but no large retrospective study has been reported. Edwards reported success with 17 of 20 cases, using four drill tracks per entry site; the earliest case returned to soundness 14 weeks after surgery.[10]

In summary, the diagnosis and treatment of tarsal disease is inherently controversial and will remain so for some time, but progress is being made, and reasonable medical and surgical options are available.

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chapter 76

Semitendinosus Tenotomy for Fibrotic Myopathy

Semitendinosus tenotomy is indicated for the treatment of fibrotic myopathy, which is characterized by a nonpainful mechanical lameness associated with a distinct gait abnormality. Horses with fibrotic myopathy have a shortened cranial phase of stride, and the affected limb is suddenly jerked caudally 3 to 5 inches just before the foot contacts the ground. The initiating cause of fibrotic myopathy is trauma with subsequent inflammation and fibrosis. Injuries from external trauma, work-related muscle damage, and intramuscular injections may cause fibrotic myopathy.[1] The disease results from fibrosis within the semitendinosus muscle and less frequently the semimembranosus, biceps femoris, and gracilis muscles. Adhesions between muscles may form and can contribute to the gait abnormality by restricting normal muscle function. When ossification of the muscles occurs, the disease is termed ossifying myopathy. Other surgical techniques for the treatment of fibrotic myopathy consist of resection of the fibrotic or ossified part of the involved muscle and transection of adhesions between surrounding muscles. The advantages of the semitendinosus tenotomy compared with resection techniques are simplicity, less disfigurement, fewer complications, and a lower recurrence rate of the gait abnormality.[2]

Anesthesia, Positioning, and Surgical Preparation

After induction of general anesthesia, the horse is positioned in lateral recumbency with the affected limb down and the opposite hind limb pulled out of the surgical field. The affected limb is left in extension. The skin immediately distal to the femorotibial joint on the caudal and medial side of the limb is clipped and routinely prepared for aseptic surgery.

Surgery

An 8-cm longitudinal skin incision is made directly over the tendon of the tibial insertion of the semitendinosus muscle on the caudomedial aspect of the crus (Fig. 76–1). The incision is made just distal to the medial femorotibial joint and just caudal to the junction of the tibia and the medial head of the gastrocnemius muscle. The saphenous vein may be adjacent to the incision. Careful palpation of the area before surgery usually reveals the location of the tendon. The incision is continued through the crural fascia until the tendon is exposed. A curved forceps or scissors is passed under the tendon, and the tendon is transected (see Fig. 76–1). After transection of the tibial insertion of the semitendinosus muscle, the extended limb should be pulled forward. In some horses, the tendon of insertion of the semitendinosus muscle onto the tuber calcis can be identified as a taut band.[3] In these horses, a second incision 3 to 4 cm long is made directly over this taut band. The second incision is caudal and slightly distal to the first incision (see Fig. 76–1).

The taut tendon of insertion is isolated by a combination of sharp and blunt dissection and is transected. Fascia and subcutaneous tissues from both incisions are closed with size 0 synthetic absorbable suture material in a simple interrupted or simple continuous pattern. The skin incisions are closed routinely.

Postoperative Management

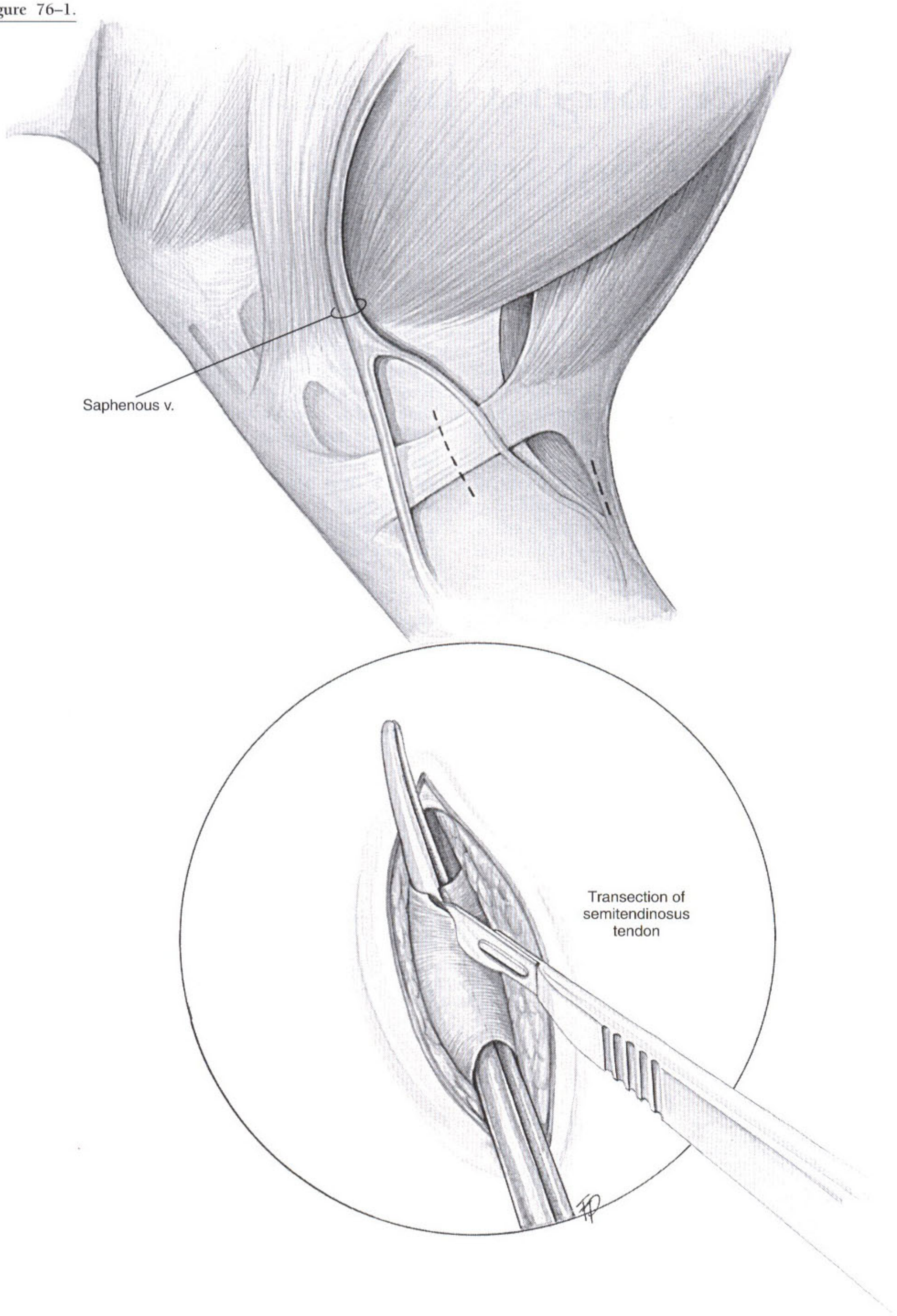
Improvement is often noted immediately after surgery.[2] Bandages are not required postoperatively. Phenylbutazone can be administered as needed to horses that are exhibiting pain. Horses should be stall rested for 2 weeks with brief periods of hand walking each day, after which light exercise can resume. Skin sutures should be removed 10 days after surgery. Unrestricted exercise can start in 6 weeks.

Complications of the surgery include seroma formation, dehiscence, infection, and incomplete resolution of the gait abnormality. The surgery is most effective when only the semitendinosus muscle is involved with the fibrotic or ossifying myopathy. In this circumstance, prognosis is good. When other muscles are involved, gait deficits may not improve completely.

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Figure 76–1.



chapter 77

Lateral Digital Extensor Myotenectomy for Stringhalt

Lateral digital extensor myotenectomy is performed for the treatment of stringhalt in horses. Stringhalt is a lameness characterized by involuntary and exaggerated flexion of the hind limbs.[1] There is a wide degree of severity of signs involving one or both hind limbs. Two forms of stringhalt have been described. Conventional stringhalt is sporadic in occurrence and may occur in one or both hind limbs with differing degrees of severity. The cause has been attributed to injuries to the metatarsus, tarsus, or stifle and to foot pain, upward fixation of the patella, spinal cord disease, and tendon adhesions. In many horses the cause cannot be determined.[2] Spontaneous recovery of horses with conventional stringhalt is uncommon.[1, 2] Lateral digital extensor myotenectomy is the recommended treatment.

Australian stringhalt, also termed the outbreak form, has been identified in Australia, New Zealand, and California. This form is usually seen during the fall season in horses on pasture and is thought to be due to ingestion of a plant toxin from the weed *Hypochaeris radicata*. Horses with Australian stringhalt usually exhibit lameness in both hind limbs and also exhibit some degree of laryngeal dysfunction. Many horses with Australian stringhalt recover spontaneously, and removal from the weed-bearing pasture is recommended.[3] Lateral digital extensor myotenectomy is not beneficial for the treatment of Australian stringhalt.

The diagnosis of stringhalt is based on observation of the characteristic gait caused by exaggerated flexion of the hind limbs.[1] Onset of the disease may be sudden. Stringhalt may be confused with momentary upward fixation of the patella. With momentary upward fixation of the patella, the exaggerated flexion is caused by the patella's catching over the medial trochlea and then suddenly releasing as the limb is being brought forward. This causes an upward jerk and increased flexion. The patella does not catch with stringhalt.

Anesthesia, Positioning, and Surgical Preparation

Lateral digital extensor myotenectomy may be performed in the standing horse using local anesthesia or with the horse in lateral recumbency after induction of general anesthesia. The method depends on the temperament of the horse and surgeon's preference. The horse should be tranquilized and the tail wrapped to prevent contamination of the surgical sites when surgery is done in the standing horse. The area over and between the surgical sites is clipped and prepared for aseptic surgery. Two incision sites are needed to remove the entire tendon and part of the muscle: one over the tendon of the lateral digital extensor on the lateral aspect of the proximal metatarsal bone, and one over the junction of the lateral digital extensor tendon and muscle belly on the lateral aspect of the crus, approximately 6 cm above the lateral malleolus of the tibia (Fig. 77–1*A*). For standing surgery, a 2-cm line of local anesthetic is injected subcutaneously over and under the lateral digital extensor tendon just before it joins the long digital extensor tendon on the proximolateral aspect of the metatarsus. This site is easily palpable just below the tarsometatarsal joint. The second area to be anesthetized is on the lateral aspect of the limb starting 6 cm above the lateral malleolus of the tibia and extending proximally. A line block 6 cm long directly over the palpable lateral digital extensor muscle is placed in the subcutaneous tissue. The anesthetic is infiltrated deeply into the fascia and muscle in the center of the line block. A total of 10 to 12 ml of anesthetic is usually sufficient. A second surgical preparation after instillation of the local anesthetic is performed.

Surgery

A 2-cm incision is made directly over the tendon just proximal to its junction with the long digital extensor tendon. The incision extends directly down to the tendon proper. Curved Kelly or Crile forceps are placed under the tendon. Another 6-cm-long incision through the skin, subcutaneous tissue, and fascia is made directly over the lateral digital extensor muscle in a longitudinal direction parallel with muscle fibers. The muscle belly is exposed, and with blunt dissection a heavy curved Kelly or Crile forceps or scissors is placed under the muscle (Fig. 77–1*B*). By pulling on the forceps underneath the muscle at the upper incision and the tendon at the lower incision, respectively, the surgeon can ensure that the correct muscle and tendon are isolated. Care should be taken to avoid cutting the long digital extensor tendon. The tendon is severed in the distal incision and is pulled through the tendon sheath by traction on the proximal forceps (Fig. 77–1*B* and *C*). This maneuver may require significant force, particularly if adhesions are present. After the entire length of the tendon has been exteriorized, the muscle and its tendon are severed in the proximal aspect of the incision, thereby ensuring that at least 2 cm of the muscle has been removed (Fig. 77–1*D*). Removal of more muscle is acceptable.

The heavy fascia of the proximal incision is closed with a simple interrupted or simple continuous pattern of size 1–0 synthetic absorbable suture material. The subcutaneous tissue is closed with size 2–0 synthetic absorbable suture using the same pattern, and the skin is closed with noncapillary, nonabsorbable suture material using a pattern of the surgeon's choice. The distal incision is closed with skin sutures only.

Postoperative Management

The wounds are covered with a sterile dressing, and a full-limb bandage extending from the coronary band to the proximal tibia is applied. The limb should be bandaged for 10 to 14 days and the horse confined to a stall for this period of time. Sutures can be removed between postoperative days 8 and 10, and hand walking can be initiated. Normal exercise can resume 3 to 4 weeks after surgery.

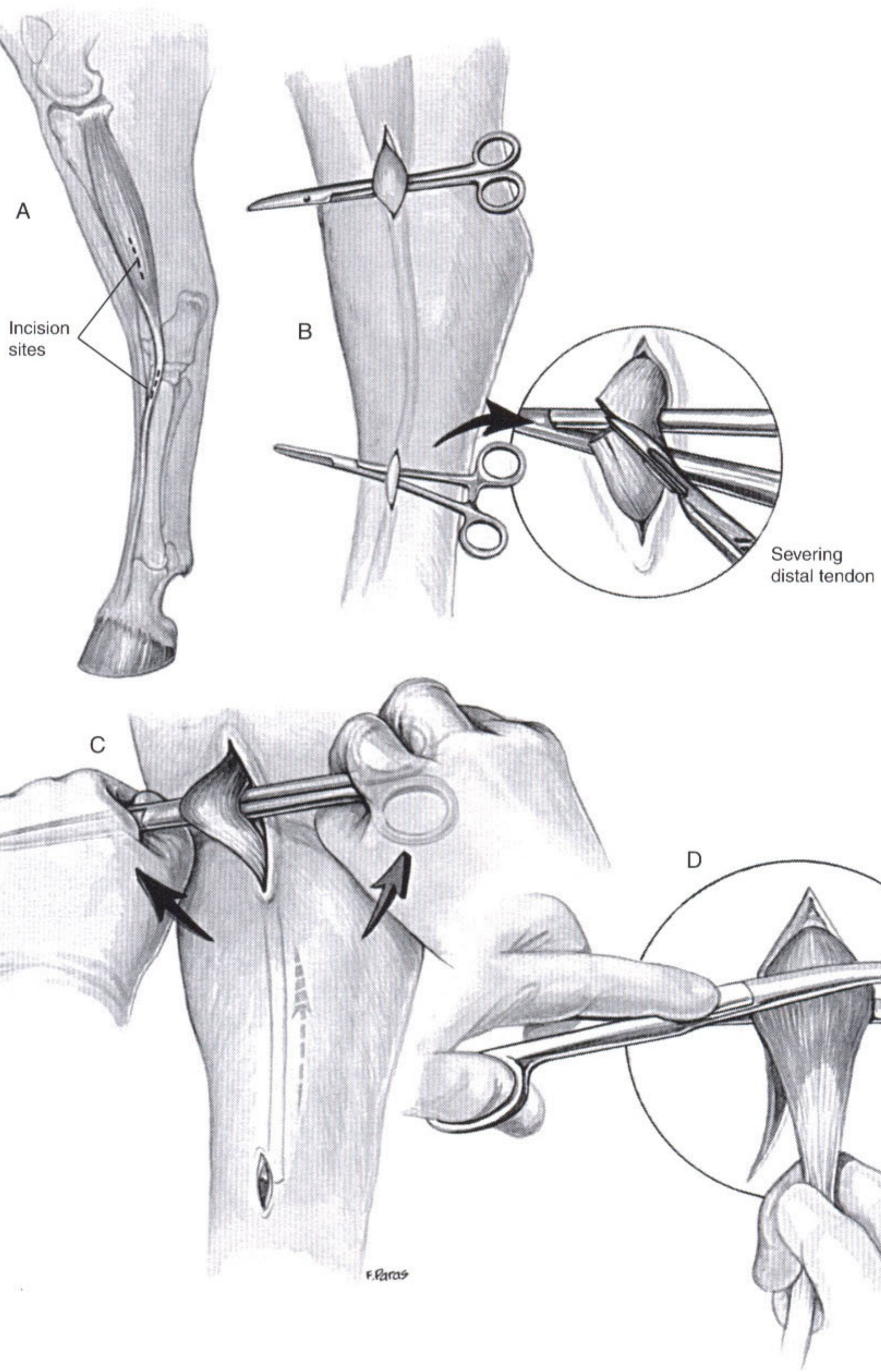
Complications after surgery include infection, dehiscence, bleeding, and seroma or hematoma formation. The high motion at the flexible hock joint may predispose to these problems. The final results of the myotenectomy are not usually apparent immediately after surgery. Improvement may occur within several days or several months.[1] Many horses show some improvement after surgery, but the degree of improvement is variable, ranging from slight to complete remission. Owners should be informed that the results of surgery are unpredictable.

A modification of the myotenectomy, whereby a large section of the muscle belly is removed and the end of the severed muscle belly oversewn, has been described.[4] This modification requires general anesthesia and a 14- to 16-cm-long proximal incision to expose the muscle belly. Proponents of this technique believe the success rate may be improved. Further studies need to be done to confirm this opinion.

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Figure 77–1.


A
Incision sites
B
Severing distal tendon
C
D
Severing muscle
F.Paras

chapter 78

Medial Patellar Desmotomy

Medial patellar desmotomy is indicated to treat upward fixation of the patella in ponies and horses.[1] Upward fixation occurs when the patellar fibrocartilage and medial patellar ligament fix, or "lock," over the medial trochlear ridge of the femur, fixing the patella on the proximal dorsal aspect of the trochlea. The diagnosis of upward fixation of the patella is based on classic postural and gait abnormalities and physical examination. The methods of diagnosis have been well described.[1] The predisposing causes of upward fixation of the patella include upright straight hindlimb conformation, poor condition, debility, and heredity. Conditioned horses rested for a few days may exhibit the problem when exercise is resumed. Horses lame in a hind limb may have secondary upward fixation of the patella in the same limb, which will resolve when the lameness resolves.

Upward fixation of the patella can be manifested in three different ways. With persistent fixation, the patella stays locked for a prolonged period of time, preventing flexion of the stifle and hock. When the horse walks, the affected limb is dragged behind. The abnormal posture is characteristic. The second type, intermittent upward fixation of the patella, occurs when the patella is fixed for a few steps followed by a period of normal locomotion. Backing the horse or walking up and down hills often causes the patella to lock. The third type of upward fixation occurs when the medial patellar ligament and fibrocartilage momentarily catch over the medial trochlea and suddenly release as the limb is protracted, causing exaggerated flexion (hypermetria) of the limb. The lameness is often noted in horses at exercise, and the gait may resemble the gait of stringhalt.

Medial patellar desmotomy is not a benign procedure.[2] Intermittent and momentary upward fixation of the patella should be treated initially with conditioning to improve quadriceps tone, anti-inflammatory drugs, resolution of underlying lameness, and injection of counterirritants around the medial and middle patellar ligaments.[3] Medial patellar desmotomy should be performed only for persistent upward fixation of the patella and intermittent upward fixation that has not responded to conservative therapy.[2] Momentary upward fixation of the patella rarely if ever requires surgery.

Anesthesia, Positioning, and Surgical Preparation

Medial patella desmotomy is best done with the horse standing with weight on the affected limb. This enables the surgeon to easily identify and define the taut medial patellar ligament. The ligament is not taut and is more difficult to identify when the horse is not bearing weight or is anesthetized. Before surgery, the tail should be wrapped in a short length to avoid intraoperative contamination of the surgical site. The hair should be removed and a surgical preparation done. We prefer to tranquilize the horse with detomidine[a] or a xylazine[b]-butorphanol[c] combination. A 20-gauge, 1½-inch needle is used to inject local anesthetic in the subcutaneous tissues between the middle and medial patellar ligaments just above the tibial crest. Anesthetic is placed cranial to the medial ligament in the subcutaneous tissues and then deep to the medial ligament. A total of 8 to 10 ml of anesthetic is sufficient. A second surgical preparation is done.

[a]Dormosedan, Pfizer Inc., New York, NY.
[b]Rompun, Bayer Corp., Shawnee Mission, KS.
[c]Torbugesic, Fort Dodge Laboratories, Inc., Fort Dodge, IA.

Surgery

A 1-cm-long incision is made just lateral to the medial patellar ligament close to the tibial tuberosity. This incision will be in a readily palpable depression between the medial and middle ligaments. The surgeon then should force a curved Kelly or Crile hemostat through the heavy fascia so it is positioned deep to the medial patellar ligament. The tip of the hemostat should be palpated subcutaneously on the medial side of the medial ligament to ensure proper position, and then the instrument is withdrawn. A blunt-tipped curved tenotomy knife[d] is now passed through the fascia behind the ligament with the cutting edge turned down and the flat side against the ligament (Fig. 78–1*A* and *B*). The knife should be kept close to the ligament to avoid penetrating the joint capsule. Once properly positioned, the tenotomy knife is rotated 90° so the cutting edge is against the ligament, and with a sawing motion the ligament is severed (Fig. 78–1*C*). The surgeon should palpate the edge of the knife in the subcutaneous tissues to confirm that the ligament has been transected. The surgeon will also note when the horse is weight bearing that, as the ligament is transected, the stifle will drop (flex) slightly as the patella is released from its fixed position over the trochlea. Once the ligament is severed, the surgeon should feel the tendon of the sartorius muscle just medial to the location of the severed medial patellar ligament. This tendon should not be mistaken for remaining fibers of the ligament and severed. Care should also be taken not to damage the medial collateral ligament of the femorotibial joint. The skin incision is closed with two or three sutures using nonabsorbable, noncapillary suture material.

Postoperative Management

Stall rest with very short periods of hand walking once or twice daily should be done for 2 weeks. The horse can then be turned into a paddock. Phenylbutazone may be administered if pain or swelling is marked. Horses should not be ridden or trained for 4 to 5 months after surgery to allow the patella to regain stability in the trochlear grove.[2] Owner compliance with this recommendation for prolonged rest is often poor.

[d]Tenotome knife, blunt-curved, Jorgensen Laboratories, Inc., Loveland, CO.

Complications

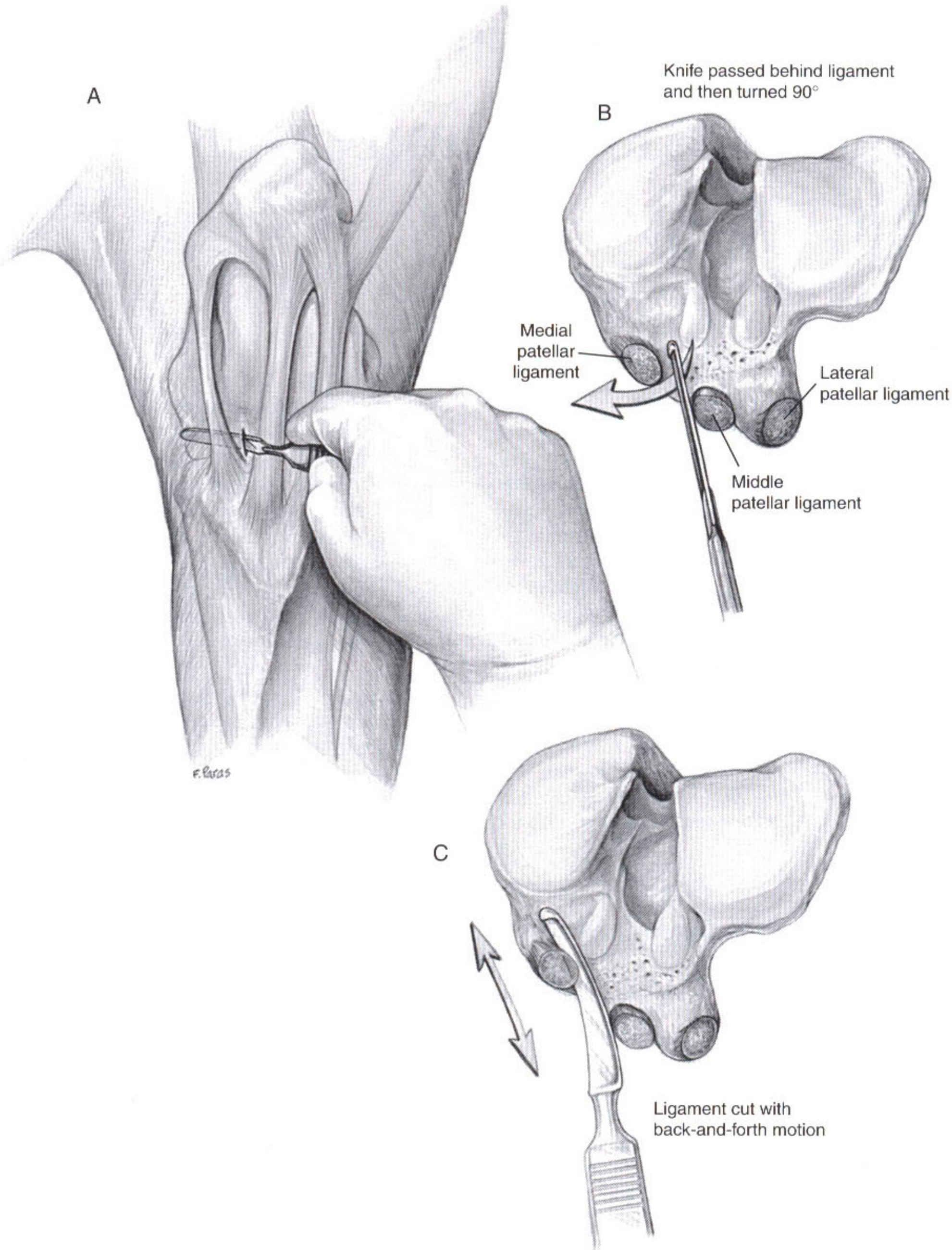
Surgical errors include penetration of the femoropatellar joint capsule, incomplete severance of medial patellar ligament, and mistaken severance of the tendon of the sartorius muscle or the medial collateral ligament. Rupture of the middle patellar ligament after surgery occurs infrequently and probably is due to increased stress on the middle patellar ligament after desmotomy of the medial ligament. The most common postoperative complication after medial patellar desmotomy is osteochondral fragmentation of the distal aspect of the patella.[2, 4] This complication is associated with femoropatellar joint effusion, capsulitis, joint stiffness, and lameness. Radiographic changes include enthesophyte formation at the attachment of the middle patellar ligament, subchondral lysis, subchondral roughening, and fragment formation at the distal aspect of the patella. Articular cartilage fibrillation is usual and can be noted arthroscopically. Treatment should include arthroscopic removal of fragmented cartilage and bone, administration of anti-inflammatory drugs, joint lavage, and rest. Horses may require 6 to 8 months to recover. The risk of patellar fragmentation should discourage surgeons from performing medial patellar desmotomy when upward fixation of the patella is infrequent or not positively identified as being a problem. When surgery is indicated, a sufficient rest period postoperatively may decrease osteochondral fragmentation.[2]

Medial patellar desmotomy is effective for eliminating upward fixation of the patella. When complications such as distal patellar fragmentation do not occur, the prognosis is excellent.

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Figure 78–1.


A
B
Knife passed behind ligament and then turned 90°
Medial patellar ligament
Lateral patellar ligament
Middle patellar ligament
C
Ligament cut with back-and-forth motion

chapter 79

Suprascapular Nerve Decompression for Treatment of Nerve Injury

The suprascapular nerve is derived mainly from the sixth and seventh cervical nerves and innervates the infraspinatus and supraspinatus muscles. The nerve emerges from the brachial plexus and passes from medial to lateral around the cranial edge of the scapula. The suprascapular nerve is adjacent to the scapula in the supraspinous fossa and is deep to the deep fascia of the supraspinatus muscle. A taut tendinous band, superficial to the nerve and attached to the scapula proximally and distally, binds the nerve to the cranial edge of the scapula.

The location of the suprascapular nerve predisposes it to compressive injury when the shoulder is traumatized.[1] Damage may be caused by direct blows to the shoulder, stretching of the nerve by sudden backward motion of the forelimb when the horse slips, and ill-fitting collars in the draft horse.[1, 2] Clinical signs vary depending on the severity of injury but usually include shoulder instability and atrophy of the supraspinatus and infraspinatus muscles. Shoulder instability is characterized by lateral movement of the scapulohumeral joint during weight bearing caused by the loss of the stabilizing function of the supraspinatus and infraspinatus muscles. Atrophy of the muscles may be apparent 7 to 10 days after trauma. This sign has commonly been termed sweeny. Immediately after injury, horses may be acutely lame from pain caused by local tissue trauma and inflammation and may not bear weight on the limb.[1, 3]

Suprascapular nerve injury should be the primary differential diagnosis for the horse with a history of shoulder trauma, atrophy of the supraspinatus and infraspinatus muscles, and instability of the shoulder.[1] The diagnosis of suprascapular nerve injury can be confirmed with electromyography. Changes on electromyography consistent with denervation should be confined to the spinatus muscles. Denervation of other muscles indicates more extensive injury. Electromyography must be performed 7 days or later after injury to the nerve to detect denervation changes in the muscle. Radiographs of the shoulder joint should be taken to rule out fractures. Neuropathy of the suprascapular nerve has been described in horses ranging in age from 1 month to 20 years.[3]

Immediately after injury to the suprascapular nerve, horses should be treated with stall rest and anti-inflammatory drugs. Surgical decompression of the suprascapular nerve may be considered if there is no improvement within 90 days of injury. Although continued stall rest is a viable alternative to surgery, producing recovery of many horses, surgery may result in a faster return to athletic function and better return of muscle mass.[4] Surgery has been successful when performed up to 1 year after injury.[1] Surgery performed on horses less than 90 days after injury may shorten the recovery period but may be unnecessary.[1]

Anesthesia, Positioning, and Surgical Preparation

Suprascapular nerve decompression is performed with the horse anesthetized and positioned in lateral recumbency with the affected limb uppermost.[5] A liberal area centered over the distal spine of the scapula is surgically prepared by clipping the hair and scrubbing the skin. A drill, drill bit, mallet, bone rasp[a] and bone chisel or a high-speed air drill[b] with a bone-cutting bur are necessary to remove bone during the surgery. We recommend the air drill. A small periosteal elevator[c] is required for surgery. Suction and electrocautery are useful for surgery but are not essential.

[a]Bone rasp no. 772, Sontec Instruments, Englewood, CO.
[b]Hall surgical micro 100 drill, Zimmer, Inc., Warsaw, IN.
[c]Crego periosteal elevator, Miltex Instrument Company, Inc., Bethpage, NY.

Surgery

A 20- to 25-cm skin incision is made just cranial to the spine of the scapula with the incision centered on the distal end of the spine (Fig. 79–1*A*). The incision is carried through the subcutaneous tissue and cutaneous trunci muscle. In some horses, the dorsal border of the brachiocephalicus muscle is noted in the distal aspect of the incision. The brachiocephalicus muscle is retracted distally after the adjacent fascia is incised on a plane parallel to the muscle fibers. The heavy fascia over the supraspinatus muscle is incised just cranial and parallel to the spine of the scapula. This fascial incision extends 6 to 8 cm distal to the spine. The supraspinatus muscle is elevated from the supraspinous fossa and retracted cranially, leaving the thick fascia deep to the muscle attached to the scapula in order to avoid damaging the nerve.

The nerve is flat and ribbon shaped. It may be nearly 2 cm wide and very thin. It courses distal to the end of the scapular spine. Careful palpation and observation allow determination of the limits of the nerve. Incisions parallel to the nerve through the deep fascia and periosteum of the scapula are made proximal and distal to the nerve as it crosses over the suprascapular fossa. Using the periosteal elevator, the periosteum, fascia, and nerve are carefully elevated together from the scapula (Fig. 79–1*B*). A ½-inch Penrose[d] drain is placed around the nerve and used as a retractor (Fig. 79–1*C*). A notch in the cranial border of the scapula, 0.5 cm wide and 2 cm long, directly beneath the nerve is made with the air drill or the bone chisel (Fig. 79–1*D*). The nerve is retracted proximally and distally to complete the notch. We prefer to use the air drill because the corners of the notch can be rounded, the size of the notch can be easily controlled, and there is no risk of fissuring the scapula by using a mallet and chisel. When a mallet and chisel are used, guide holes are drilled at the top and bottom corners of the intended notch, and the bone should be removed in a distal to proximal direction to avoid initiating a fracture, which might extend into the supraglenoid tubercle. After removal of bone with a mallet and chisel, the edges of the defect are smoothed with a bone rasp.

The superficial tendinous band cranial to the nerve is identified by palpation. This band is between the supraspinatus and subscapularis muscles and may be difficult to visualize. The band is severed with Metzenbaum scissors proximal to its attachment to the supraglenoid tubercle (Fig. 79–1*E*). The scapular notch and transection of the tendinous band provide more space for the nerve and release it from restrictions next to the cranial edge of the scapula.[1] The Penrose drain is removed, and the wound is liberally flushed with sterile fluids. The heavy fascia of the supraspinatus muscle is sutured to the fascia on the scapular spine using size 0 polydioxanone[e] monofilament suture material in a simple continuous pattern. The brachiocephalicus muscle is sutured to the adjacent fascia, and the cutaneous trunci muscle is closed using size 0 suture material. The subcutaneous tissue is closed with size 2–0 absorbable suture material with a simple continuous pattern, and the skin is closed with a nonabsorbable monofilament suture material in any acceptable pattern of the surgeon's preference. A stent bandage is sutured in place over the wound to provide protection for the first 2 days after surgery.

Postoperative Management

Recovery from anesthesia should be assisted when possible to reduce the chances of supraglenoid tubercle fracture or scapulohumeral dislocation. Phenylbutazone should be given for 10 to 14 days to control pain and inflammation around the suprascapular nerve. Postoperative stall rest is recommended. Depending on the severity of shoulder instability, the rest period may last from 2 weeks to 4 months. Forced exercise of a horse with marked shoulder instability may increase the risk of osteoarthritis. When the shoulder joint begins to stabilize, a controlled exercise program can begin.[1] Exercise is gradually increased as muscle strength returns and shoulder stability improves.

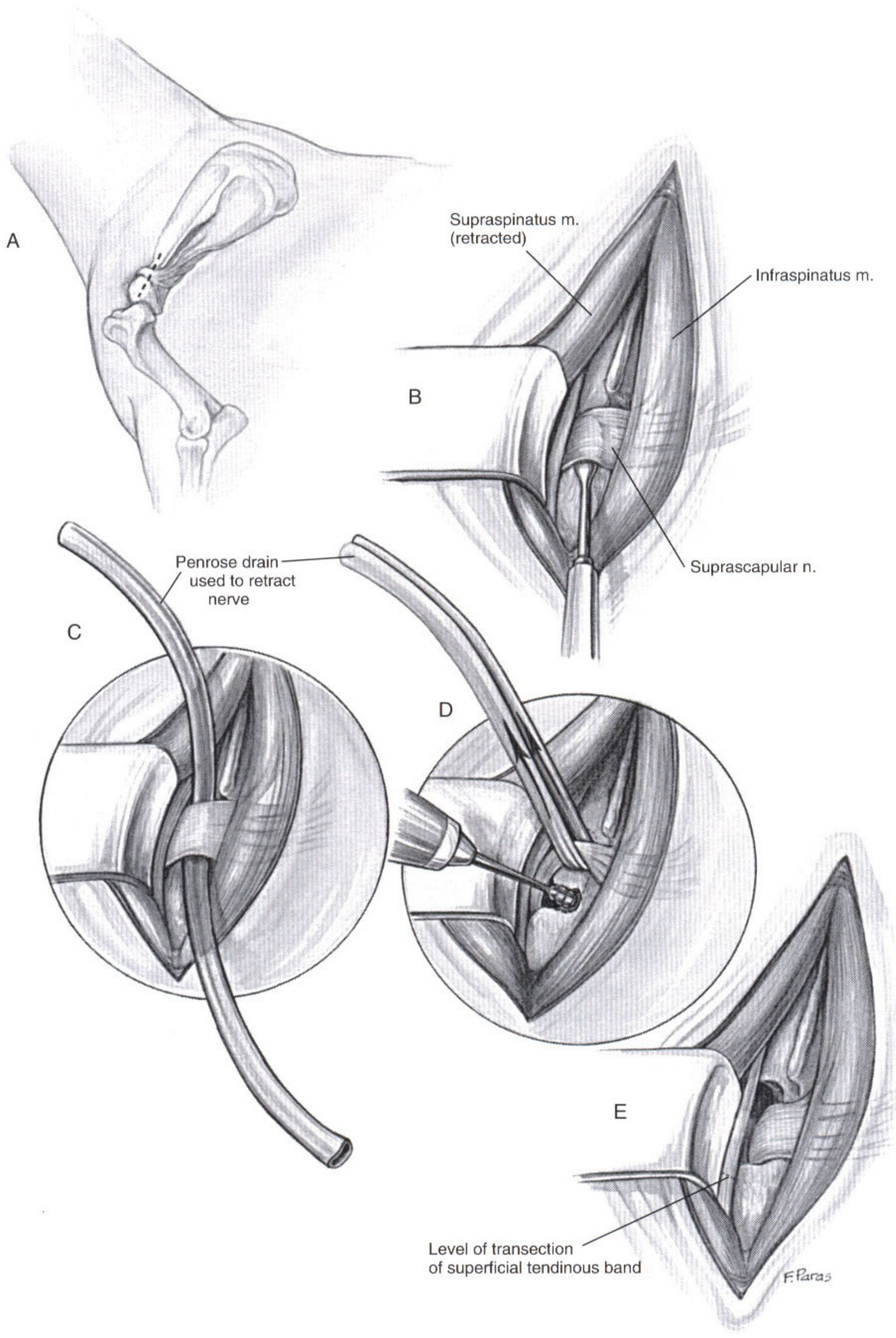
The major complication to surgery is fracture of the supraglenoid tubercle. Fracture is possible because the cranial strut of the neck of the scapula, which supports the tubercle, is weakened by the notching procedure. Fracture may occur during recovery or at any time during the postoperative period. Fracture of the tuberosity has been reported 6 weeks after surgery in a horse confined to a stall.[1] Other complications include wound infection, seroma formation, wound dehiscence, and continued paralysis.

The prognosis after surgery is generally good, particularly when surgery is performed within the first year after injury. In one report, 18 of 20 horses undergoing surgery regained athletic soundness.[1] However, residual muscle atrophy was noted in 12 of the 18 horses. Nerve function and stability of the shoulder usually return in 3 to 4 months, but improvement has been noted to take up to 1 year after surgery.[2]

[d]Latex Penrose tubing, Sherwood Davis & Geck, St. Louis, MO.

[e]PDS II, Ethicon, Inc., Somerville, NJ.

Figure 79–1.


A
Supraspinatus m.
(retracted)
Infraspinatus m.
B
Suprascapular n.
Penrose drain
used to retract
nerve
C
D
E
Level of transection
of superficial tendinous band
F. Paras

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chapter 80

Regional Antibiotic Perfusion

Bacterial infections of the bones, joints, and synovial sheaths of the equine limb are difficult to treat. The prognosis for soundness is guarded, and many horses are eventually euthanatized.[1, 2] Elimination of bacteria by systemic administration of antibiotics often is unsuccessful, and the antibiotics can be expensive and potentially toxic.[2] Systemic antibiotic therapy may be unsuccessful because of low blood flow in infected tissue. Bacteria in a joint can colonize the synovial membrane and cause vascular thrombosis and necrosis. Dense avascular scar and necrotic bone often occur as the result of osteomyelitis. These vascular injuries with resultant areas of ischemia isolate bacteria from the immune defense mechanisms of the body and from systematically administered antibiotics. Low tissue and fluid pH in infected areas may decrease the activity of aminoglycoside antibiotics. This necessitates higher levels of antibiotics to kill the bacteria than would be necessary at a normal pH.

Methods of local or regional antibiotic delivery, which result in much higher concentrations of antibiotics in infected tissues than can be achieved by systemic administration, include direct intrasynovial administration of antibiotics, implantation of antibiotic-impregnated polymethylmethacrylate beads,[3] and regional perfusion.[1, 2, 4, 5] Regional perfusion is done by the intravenous or intraosseous injection of an antibiotic directly into the deep venous system of the limb adjacent to the infected tissue.[1, 2, 6] A tourniquet placed above the infected area confines the antibiotic to the region involved. Antibiotics enter the deep venous system in high levels and diffuse into adjacent healthy and ischemic tissues. Regional perfusion in horses in two experimental studies resulted in peak levels of antibiotics in the perfused tissues greater than that achieved by systemic administration.[1, 2]

Regional perfusion should be used as an adjunct to standard methods of treatment of septic synovitis, septic arthritis, and osteomyelitis. Standard methods include systematic antibiotic delivery based on bacterial isolation and sensitivity testing, direct intrasynovial administration of antibiotics, drainage and lavage, curettage of necrotic bone, immobilization, and the removal of implants no longer contributing to stability. Regional perfusion allows small doses of antibiotics to be given in a manner that achieves high regional tissue levels. This effect may reduce systemic toxicity and increase the potential for diffusion of the antibiotics into ischemic tissues. Indications for regional perfusion include sepsis in all joints of the limbs distal to and including the carpus and tarsus, and osteomyelitis of bones distal to and including the radius and tibia. Specific diseases that have responded to regional perfusion in horses include osteomyelitis of the metacarpus, metatarsus, radius, and tibia associated with implantation of bone plates for treatment of fractures; sepsis of the carpus, tarsus, fetlock, and distal interphalangeal joints; septic tenosynovitis; septic navicular bursitis; osteomyelitis of the sesamoid bones; osteomyelitis of the distal phalanx caused by puncture wounds of the hoof or by septic laminitis; and physeal infection in foals.[4, 7]

Success of regional perfusion depends on the use of antibiotics that are effective against the bacteria present in the tissues and the administration of doses sufficient to achieve high tissue levels. Antibiotic selection for regional perfusion should be based on isolation of bacteria from infected tissues and sensitivity testing. Perfusion of the distal limb in horses with 125 mg of amikacin,[a] using a tourniquet placed just above the fetlock, provides effective tissue levels of amikacin in the coffin and fetlock joints and navicular bone.[2] Perfusion of the limb with 1 g of gentamicin[b] using a tourniquet placed above the carpus in adult horses results in high antibiotic levels in synovial fluid and synovial membrane of the carpus.[1] In general, we recommend 125 to 150 mg of amikacin or gentamicin for distal limb perfusion in horses of all weights and up to 1 g of these antibiotics for perfusion of the full limb. However, to avoid systemic toxicity, doses of gentamicin or amikacin should never exceed the recommended dose based on body weight for a single intravenous injection. Other antibiotics that have been used for regional perfusion include sodium ampicillin, sodium penicillin, and cefazolin. Only antibiotics approved for intravenous administration should be used for regional perfusion.

Regional perfusion of antibiotics may be done by entering the venous system via a peripheral vein or by intraosseous cannulation with an infusion needle. The intraosseous route often is chosen for regional perfusion of tissues above the fetlock. For intraosseous cannula-

[a]Amiglyde-V, Fort Dodge Laboratories, Inc., Fort Dodge, IA.
[b]Gentocin, Schering-Plough Animal Health Corp., Kenilworth, NJ.

tion, the medullary cavity of the affected bone or an adjacent bone is entered. The antibiotics are instilled directly into the medullary venous system. Repeated perfusions can be done using the same hole. The intravenous route is the usual choice for regional perfusion of the digit. The digital vein directly over the sesamoid bone is the most common site of catheterization for intravenous regional perfusion. This technique requires no special equipment but may result in loss of patency of the vein.

Anesthesia, Positioning, and Surgical Preparation

Horses should be anesthetized, but the technique has been performed in the standing horse. Any position that allows access to the affected limb for osseous cannulation or venous catheterization and for application of an Esmarch bandage[c] tourniquet is suitable. The position is usually determined by other procedures such as joint lavage, bone curettage, or implant removal that are scheduled for the same anesthetic period. The infusion site should be clipped for hair removal, surgically prepared, and draped.

Intraosseous regional perfusion requires a cannulated infusion needle[d] for insertion into the bone. Initially intraosseous perfusion in horses was performed using an angiographic injector[e] adjusted to deliver a 60-ml volume of antibiotic solution at 2 ml/min with a maximum infusion pressure of 450 psi.[1,4] We no longer use this pump routinely, preferring hand injection using a 60-ml syringe instead. Little pressure is required to deliver the solution in most horses.

Surgery

Intraosseous Regional Perfusion

The medullary cavity of the third metacarpal metatarsal bone is most often cannulated for intraosseous regional perfusion. Intraosseous perfusion is used most commonly to treat infections of the metacarpus, metatarsus, hock, and carpus. The tibia and radius are perfused by placing an infusion needle directly into these bones. Cannulation of the metacarpus for regional perfusion of the carpus is begun by drilling a 3.2-mm-diameter hole through one cortex of the distal third of the metacarpal bone in an area that is devoid of tendons. A 1-cm stab incision through the skin, subcutaneous tissues, and periosteum is made, and these tissues are separated with a hemostat while the hole is being drilled. A threaded, self-tapping cannulated infusion needle is screwed into the hole (Fig. 80–1*A*). A sterile Esmarch bandage is wrapped around the limb beginning at the hoof and extending proximally to the distal radius just above the carpus. The bandage is wrapped very tightly except over the carpus, where it is loosely wrapped to allow the efflux from the osseous venous system to enter the synovial venous system of the carpus, thereby perfusing soft tissues.[1] To maintain the perfusate in the limb, the Esmarch bandage should be wrapped around the distal radius four or five times as tightly as possible. Alternatively, a pneumatic tourniquet can be placed at this level (Fig. 80–1*B*). The selected antibiotic is delivered by slow injection over 3 to 5 minutes in a 60-ml volume of balanced electrolyte solution using a large syringe. The cannulated infusion needle is closed with a stopcock or injection port, and the tourniquet is left in place for 30 minutes to keep the antibiotic in the venous system of the diseased region of the limb. Afterward, the tourniquet is released, and the infusion needle is removed from the bone.

The antibiotic perfusate can be forced into different areas of the limb by altering the method of Esmarch bandage application.[5] To perfuse the distal limb, the Esmarch bandage is wrapped tightly from the hoof to the proximal metacarpus metatarsus above the point of the needle insertion and secured by wrapping tightly four to five times around the limb and tucking the remaining roll under the last wrap. This forces blood out of the superficial digital vasculature.[2] The bandage is then unwrapped from the digit up to the level where it is secured tightly around the limb, and 60 ml of antibiotic perfusate is injected into the medullary cavity via the infusion needle. This method maintains the perfusate in the venous system of the distal limb. The tourniquet is removed after 30 minutes.

Intravenous Regional Perfusion

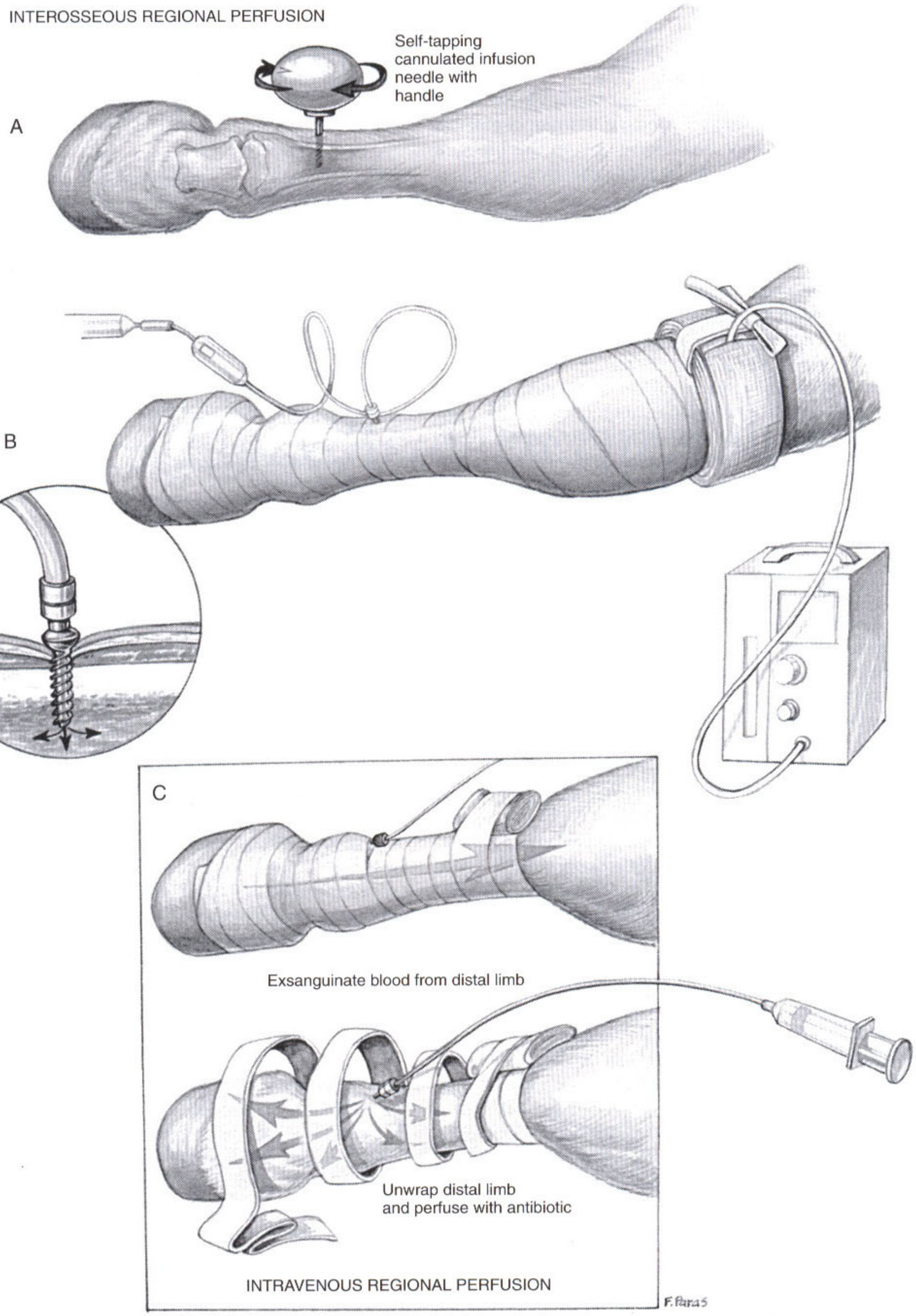
This method has been shown to be effective for perfusion of the distal limb in horses.[2] A 20-gauge, 1-inch-long over-the-needle catheter is introduced into the medial or lateral palmar or plantar vein at the level of the proximal sesamoid bones. When the vein cannot be readily identified, a small incision through the skin directly over the vein will facilitate catheter insertion. The catheter is heparinized, capped, and secured with a suture or with methylmethacrylate glue. An Esmarch bandage is wrapped tightly around the limb from the hoof to the metacarpal or midmetatarsal region and secured with four or five tight wraps and tucking the roll under the last wrap (Fig. 80–1*C*). The Esmarch is

[c]Esmarch bandage, American Hospital Company, McGaw Park, IL.

[d]Sur-Fast Intraosseous Infusion Needle, Cook Veterinary Products, Inc., Bloomington, IN.

[e]Mark IV angiographic injector, Medrad, Pittsburgh, PA.

Figure 80–1.


INTEROSSEOUS REGIONAL PERFUSION
A
Self-tapping cannulated infusion needle with handle
B
C
Exsanguinate blood from distal limb
Unwrap distal limb and perfuse with antibiotic
INTRAVENOUS REGIONAL PERFUSION
F. Paras

then unwrapped from the hoof to the level of the proximal wraps. The antibiotic is diluted in 60 ml of balanced electrolyte solution and is injected over a 2- to 3-minute period, after which the catheter is capped (see Fig. 80–1*C*). After 30 minutes, the tourniquet is released and the catheter is removed.

For perfusion of the carpus or tarsus via the intravenous route, the Esmarch bandage tourniquet extends above these joints. At these locations on the limbs, a pneumatic tourniquet may be more effective.

Postoperative Management

No specific postoperative care is required for regional perfusion. However, standard methods of treatment for infection of bone, joints, sheaths, or bursae should be continued. After release of the tourniquet, the antibiotics enter the systemic circulation and are widely distributed. When the antibiotic dose for regional perfusion is equivalent to the systemic dose, systemic antibiotics should not be administered at the same time if there is a potential for toxicity.

Generalized thrombosis of the venous system distal to the tourniquet may occur if irritating antibiotic solutions or massive doses of antibiotics are used for the regional perfusion. Studies are needed to determine optimum types and dosages of antibiotics and the schedule for repeated regional perfusions. This technique has been a useful adjunct for treatment of chronic septic conditions of the lower limbs of horses in our practice.

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Abdominal Wall Surgery

chapter 81

Umbilical Herniorrhaphy

Umbilical hernias are the second most common congenital defect in horses, and surgical correction of uncomplicated, reducible hernias is practiced as a field procedure by both general practitioners and equine specialists.[1] Umbilical hernias consist of a sac of peritoneum, subcutaneous tissue, and skin; contents, which are usually small intestine; and a midline defect in the body wall. The defect is commonly 5 to 7 cm in length. Thoroughbreds, Standardbreds, and Quarter horses are commonly affected; females are twice as likely as males to be affected. The genetics of umbilical hernia in the horse is uncertain but involves a sex-linked factor.[1] Not all umbilical hernias require surgical correction. Some hernias close spontaneously. Some close in response to mild irritation, such as daily manipulation, or the use of a truss. Umbilical hernias that persist until the foal is 5 to 6 months of age, those that gradually enlarge over time, and those that fail to respond to conservative management are candidates for elective surgical correction.

Although most of these hernias are uncomplicated, reducible, and benign, between 8 and 10% of umbilical hernias referred to tertiary hospitals sustain complications that are life threatening and mandate emergency surgery.[2–4] Horses with hernias that suddenly increase in size, become edematous or painful, or are associated with depression or colic warrant urgent clinical evaluation and exploratory surgery. Intestinal incarceration-strangulation, umbilical abscesses, and parietal hernias, wherein the antimesenteric border of intestine is incarcerated but the lumen remains patent, may cause acute crises. Although the complications of umbilical hernias usually are sudden in onset and acute in nature, incarceration (nonreducible hernias) or infection can persist for a variable period of time before the indolent changes lead to the point of crisis. Enterocutaneous fistulas are rare complications that usually occur as a result of umbilical herniorrhaphy but have been known to develop spontaneously, presumably after incarceration of a parietal hernia.[5] Necrosis of the incarcerated bowel wall leads to abscess and fistula formation without completely obstructing the bowel lumen. Enterocutaneous fistulas can be benign, or they can result in massive losses of fluid and electrolytes with major pathophysiologic disturbances. Iatrogenic causes of enterocutaneous fistulas include improper use of hernia clamps, injection of irritants around the hernia, and mistakenly lancing bowel, believing the mass to be an umbilical abscess. Careful evaluation of umbilical masses by palpation, aspiration, and ultrasonography can prevent such errors. Palpation with the foal in dorsal recumbency, wherein tension on the mass and the abdominal wall is lessened, provides a reliable impression of the nature of the involvement.

The criteria for proper surgical repair of an umbilical hernia are the obliteration of the hernial sac and the repair of the defect in the abdominal wall. Hernia clamps and the injection of irritating substances have been used to treat umbilical hernias, but they obliterate only the sac, thus satisfying one of the two criteria.

Abdominal Wall Surgery

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Irritants create necrosis as a means of inducing inflammation and healing, thus carrying the risks of reherniation, the formation enterocutaneous fistula, and even evisceration.

Anesthesia, Positioning, and Surgical Preparation

Simple, uncomplicated, reducible umbilical hernias can be repaired by using either continuous intravenous anesthesia or inhalation anesthesia. Depending on the size of the defect in the body wall to be repaired and the experience of the surgeon, anesthesia may need to last up to 45 to 60 minutes. The horse should be groomed and have its feet cleaned before being positioned in dorsal recumbency and prepared for aseptic surgery. A wide area is clipped and routinely scrubbed for surgery. The prepuce in males should be closed with towel clamps and the feet and distal limbs covered. Even in a field environment, impervious draping, hand scrubbing and the donning of sterile surgical gloves, and the use of autoclaved instruments are indicated to preclude postoperative infection.

Surgery

Surgical repair is started by making a longitudinally oriented elliptic incision around the sac through the skin and subcutaneous tissue (Fig. 81–1*A*). The ellipse needs to be narrow enough to allow easy apposition of skin edges during closure. Metzenbaum scissors are used to effect a sharp-blunt dissection of the skin and subcutaneous tissue from the peritoneal layer of the sac (Fig. 81–1*B*). The sac is dissected free to the limits of the hernial ring or defect in the body wall. Small peritoneal sacs, the size of a tennis ball or smaller, are inverted into the abdominal cavity and not opened (Fig. 81–1*C*). The sac atrophies, and keeping it closed precludes potential contamination of the abdomen. Larger peritoneal sacs may undergo an ischemic necrosis with localized aseptic peritonitis and should be excised flush with the hernial ring rather than inverted. In either event, it is not necessary to deliberately "roughen" the fascia to aid healing of the body wall defect. The dissection necessary to isolate the peritoneal sac is sufficient inducement of fibroplasia to effect secure healing of the defect. Usually, hemorrhage is minimal, but the occasional patient has two to three subcutaneous vessels of sufficient magnitude to require clamping with hemostats. Ligatures are seldom required.

A layered closure is used to suture the tissues. Far-near-near-far tension sutures of size 2 polydioxanone[a] are used to appose the body wall defect (Fig. 81–1*D*). Horses with thin edges around the hernial ring require wide placement, up to 3 cm, of the far throws to incorporate the strong fascia of the rectus abdominis. The stitches are placed 1.0 to 1.5 cm apart. Between three and five tension sutures are required for most hernias. The far-near-near-far sutures can be staggered with simple interrupted sutures in many cases in which the defect is smaller and the body wall thickness adequate. Very small defects, less than 3 cm, can be closed with simple interrupted stitches alone. For the occasional larger hernia, the tension sutures are preplaced and then pulled up together and tied. The subcutaneous tissues and skin are closed as separate layers using a suture material and pattern of the surgeon's choice. We prefer size 2–0 polydioxanone in a simple continuous pattern with careful obliteration of subcutaneous dead space to preclude seroma formation. A subcuticular stitch in the skin, using the same material, obviates stitch removal. An adhesive drape[b] can be used to protect the incision during and immediately after recovery from anesthesia.

Postoperative Management

Provided that aseptic precautions are followed, herniorrhaphy is classified as a clean surgery and antibiotics are unwarranted. Nonsteroidal anti-inflammatory drugs may be helpful, but most of these patients exhibit little or no postoperative discomfort. Tetanus immunization status should be current. A truss or body bandage is unnecessary and, because of the prepuce in males and the flank folds, troublesome to apply. Complete pasture freedom should be prohibited for 3 weeks after surgery, but the extent of stall confinement can be determined by the size and age of the patient, the size of the original hernia, and the facilities available.

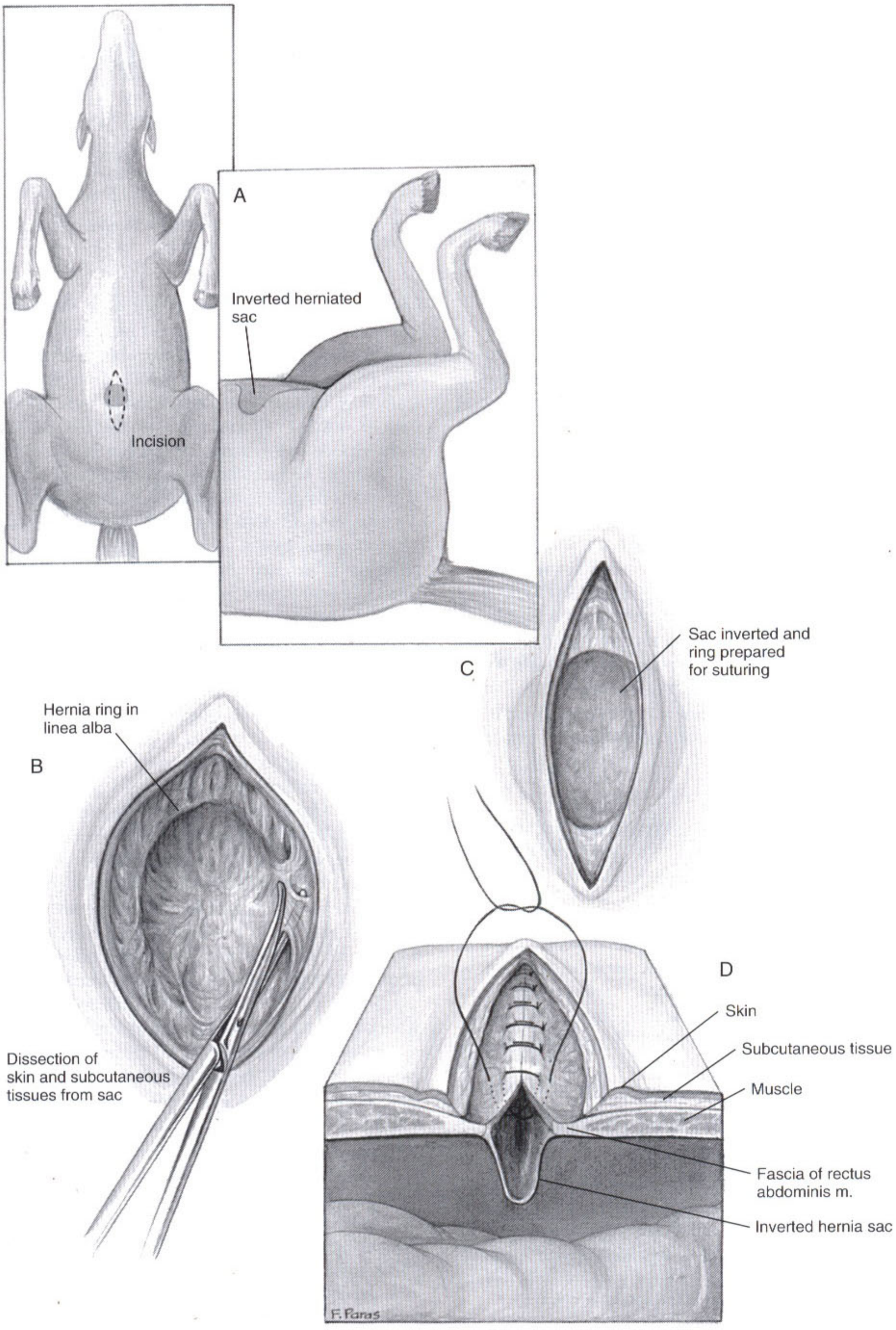
Complications of herniorrhaphy are infrequent if the surgery has been performed with judicious attention to detail. Hematomas signal inadequate hemostasis intraoperatively. Seromas signal inadequate obliteration of subcutaneous dead space. In the absence of local tenderness and persistent inflammation, these problems usually regress spontaneously, and the surgeon is encouraged to adopt a "wait and see" approach. Because otherwise benign seromas or hematomas are easily converted to abscesses, needle aspiration or lancing of large fluctuant subcutaneous swellings that persist after umbilical herniorrhaphy, particularly when there has been primary healing of the skin, should be deferred for at least 12 to 14 days after surgery. This allows fibroplasia to isolate and "insulate" the deeper tissues from such intervention.

Subcutaneous infection will result in inflammation and tenderness at the incision site and moisture or

[a]PDS II, Ethicon, Inc., Somerville, NJ.

[b]Ioban 2 antimicrobial film, Animal Care Products, 3M Health Care, St. Paul, MN.

Figure 81–1.


A
Inverted herniated sac
Incision
C
Sac inverted and ring prepared for suturing
Hernia ring in linea alba
B
Dissection of skin and subcutaneous tissues from sac
D
Skin
Subcutaneous tissue
Muscle
Fascia of rectus abdominis m.
Inverted hernia sac
F. Paras

discharge at the stitches. Warm hydrotherapy and parenteral antibiotics may be indicated. One or two skin sutures should be removed to assist drainage. Fortunately, subcutaneous abscesses can form and be drained without jeopardizing the integrity of the body wall closure. However, the persistent inflammation that accompanies unresolved infection delays the return of tensile strength during the maturation phase of healing, thus predisposing the patient to reherniation.

Umbilical herniorrhaphy is a straightforward procedure with an excellent prognosis for life and function at any level of activity.

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chapter 82

Mesh Repair of Large Body Wall Defects

Large defects in the body wall of horses are uncommon, but they can be a complication of celiotomy or can follow external trauma. Neglected umbilical hernias can become very large by the second or third year of life, and older broodmares may sustain a ventral herniation or rupture of the prepubic tendon in late pregnancy.[1] Incisional hernias may form shortly after surgery as a result of wound dehiscence or may be delayed when caused by infection. Delayed incisional hernias are evident as early as 3 months after surgery, and their incidence is significantly associated with incisional edema, drainage, infection, the use of chromic catgut or braided nonabsorbable suture material, and previous celiotomy.[2, 3] Postoperative infection of a ventral midline laparotomy incision interferes with the return of tensile strength during the maturation phase of healing. The weaker fibrous tissue may result in a hernia that becomes apparent weeks to months after surgery.

Timing the surgical repair of a large body wall defect is critical to a favorable outcome. All infection and drainage must be completely resolved for at least 60 days before surgery. It may be necessary to remove deep sutures and knots that have abscessed and fistulized to the skin as a separate, preliminary procedure to help the resolution of chronic infection. We have experienced the persistence of catgut, as well as nonabsorbable materials, in the presence of chronic infection and inflammation. Antibiotic therapy may be helpful but is insufficient alone to resolve the infection around buried suture material.

Traumatic hernias and ruptures, such as prepubic tendon ruptures, must be completely healed before mesh repair can be accomplished. The initial injury is associated with ischemic devitalization, shredding, hemorrhage, and edema of the tissues, all of which preclude secure suture placement and repair. Barring intestinal obstruction-strangulation or some other acute crisis, repair is postponed until solid fibrous margins of the defect are identifiable by palpation. The longer the repair can be delayed, the easier the surgery and the greater the chances for success. Owners tend to be impatient, but a 3- to 4-month delay is minimal; a 6- to 8-month delay is optimal.

Surgical correction of large hernias or body wall defects may be by primary closure or by mesh herniorrhaphy.[1] It is surprising how frequently it is possible to reconstruct the body wall with far-near-near-far sutures and a layered closure (see Chapter 81). For this type of primary closure, most of the scar tissue is removed and tension sutures are placed in normal fascia around the margin of the defect.[4] It is essential to preplace the sutures and pull them up together to provide even distribution of tension in the body wall before tying knots. If many sutures are preplaced, a surgical assistant is necessary to assist with placing tension on the sutures to oppose the margins of the defect while each individual suture is tied. Large hernias that are under considerable tension are repaired with mesh. The final decision about the need for mesh is made with the horse in dorsal recumbency, which affords the best palpation of the defect. Occasionally, the defect must be completely dissected before the method of closure is chosen.

Anesthesia, Positioning, and Surgical Preparation

It is important to reduce the intestinal contents before surgery. The patient should have free access to water, but all feed is withheld for 48 to 72 hours. Prolonged fasting, combined with the stresses of anesthesia and surgery, predisposes these horses to postoperative diarrhea. The administration of one-half gallon mineral oil per os 12 to 24 hours before surgery helps to protect against the gastrointestinal insult created by fasting. Because a foreign body (mesh) is to be implanted in many horses that have had previous infection of the tissues, perioperative antibiotics are indicated. Penicillin G potassium,[a] 22,000 U/kg as an intravenous bolus just before the induction of anesthesia and repeated within the first 2 hours after surgery, provides suitable tissue levels of antibiotic during the decisive

[a]Penicillin G potassium, Bristol-Myers Squibb Co., Princeton, NJ.

period of surgical intervention. The continuation of antibiotics beyond the first 24 hours after surgery or the use of broad-spectrum antibiotics as part of the perioperative regimen has not been documented as useful when operating on previously infected but otherwise healed tissues. Because of the chance of infection that could lead to mesh rejection and reherniation, careful aseptic technique, including full surgical attire and complete draping of the horse, is essential.

Inhalation anesthesia is recommended to provide the safety and time required to perform mesh repair of a large body wall defect. Most large defects involve the ventral abdomen, and the patient must be in dorsal recumbency. The herniated region is widely clipped and routinely prepared for aseptic surgery. Hair should be removed from the prepubic region to well forward on the thorax to allow for a liberal incision with good exposure of the defect and the possibility for lengthening the incision.

Surgery

For mesh implantation, a longitudinal incision of skin and subcutaneous tissue is centered over the defect and extends from normal tissue to normal tissue on each side (Fig. 82–1*A*). If repairing an incisional hernia, the incision is made through the previous scar in the skin. The subcutaneous tissues are dense and fibrous, having been altered by the previous injury or surgery, and require a combination of knife incision and sharp dissection with Mayo scissors.[b] Fibrous adhesions tend to form between the intestine and the peritoneal surface of these defects. The cecum or large colon frequently is involved. The abdominal cavity must be opened through adjacent normal peritoneum, the defect explored, and adhesions dissected free. The thickened fascioperitoneal tissue that comprises the "sac" of these defects is divided longitudinally into fascial flaps that are preserved for the mesh reconstruction (see Fig. 82–1*A*).

A variety of mesh materials are available commercially. Metal meshes such as stainless steel or tantalum are not recommended in horses because of poor working qualities and incompatibility in the presence of infection. Woven plastic mesh and knitted polypropylene mesh[c] have been used in horses.[5] Although it is considerably more expensive, we prefer the polypropylene mesh primarily because the knitted product contours well, but we have used both products successfully.

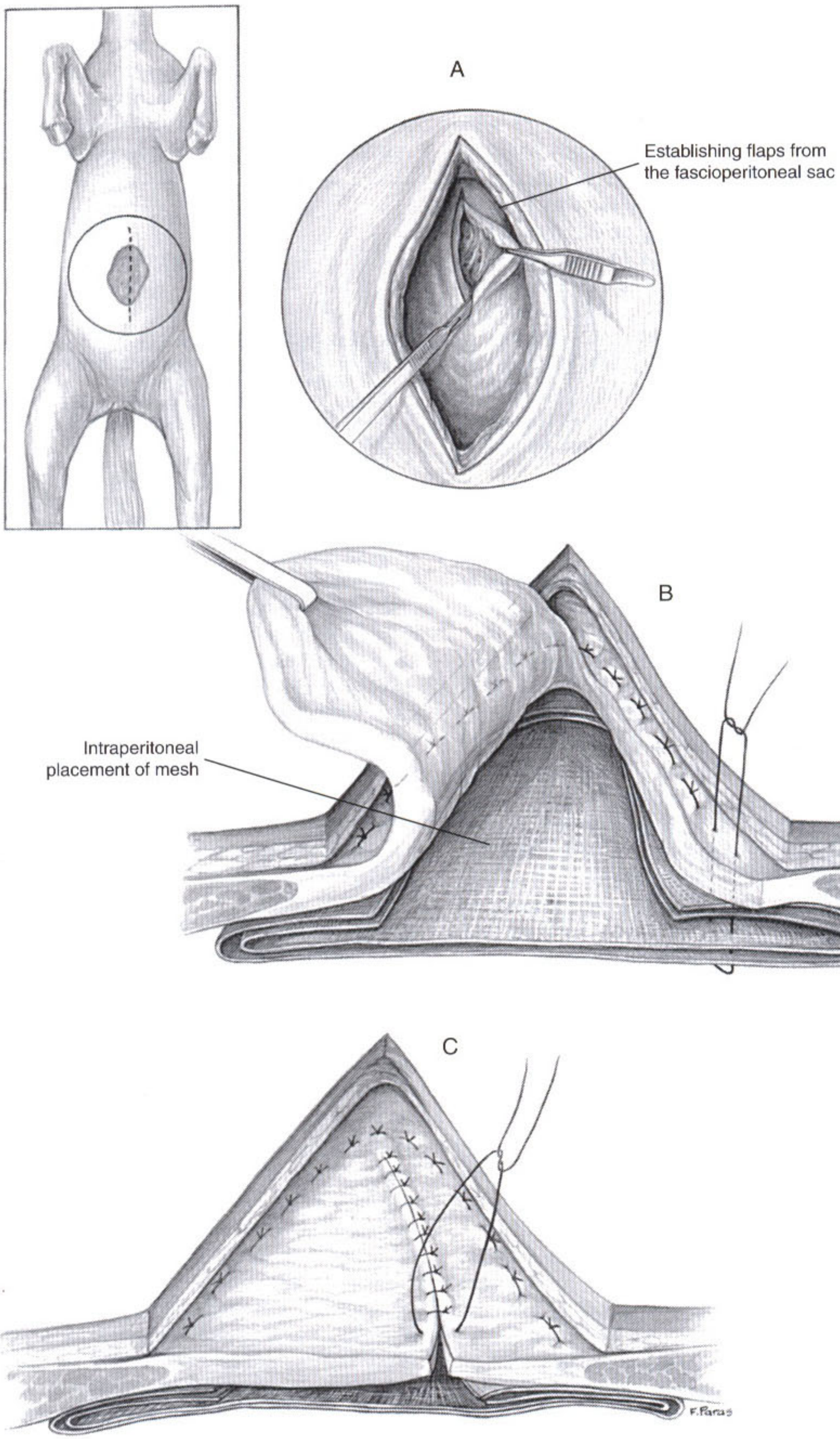
Mesh can be positioned intraperitoneally, retroperitoneally between fascial flaps, and subcutaneously. Practically speaking, it is difficult to identify, dissect, and maintain a separate peritoneal layer to prevent contact of the mesh with intestines. Even though there is a tendency for adhesions between bowel and mesh, intraperitoneal placement of the mesh is satisfactory (Fig. 82–1*B*). Such deeply placed mesh is less likely to become infected. A double layer of mesh is created by folding one edge and cutting the remaining edges to a 2.5-cm oversize to fit the body wall defect. With the use of large, preplaced horizontal mattress sutures of size 1 or 2 monofilament synthetic nonabsorbable suture material,[d] the mesh is positioned in the defect (see Fig. 82–1*B*). These sutures should be up to 2.5 cm back from the defect margin, 2 cm wide, and 2 cm apart. They should penetrate a folded border of mesh (four layers) and the full thickness of the body wall (see Fig. 82–1*B*). The folded borders are placed externally, and the sutures are placed and pulled up to effect smooth, even tension on the mesh to preclude wrinkles. Careful implanting of the mesh improves support, reduces tissue reaction, and enhances mesothelial overgrowth with healing.

The poorer, thinner, or weaker of the fascioperitoneal flaps is resected from the defect margin and discarded. The better flap is sutured to the opposite defect margin as an onlay covering of the mesh with simple interrupted sutures of size 1 or 2 polydioxanone[e] (Fig. 82–1*C*). In very large defects, both flaps can be used with a layer of mesh between, but most smaller midline defects require a single onlay over the mesh. Although the occasional defect mandates the subcutaneous location of mesh, and we have so located it on rare occasion, such a superficial position of the mesh should be avoided whenever possible because of the natural presence of organisms in the dermis, the greater risk of infection, and the weaker biomechanical position of the mesh.

In addition to careful asepsis, thorough hemostasis, careful tissue handling, and repeated intraoperative lavage are essential. Suction and electrocoagulation equipment assist in maintaining a suitable surgical field. Copious lavage of the tissues with polyionic solution to remove blood clots and to keep tissues moist, particularly during wound closure, helps to prevent infection. Redundant skin is excised and tailored for suture. The subcutaneous closure must obliterate dead space. Careful skin apposition aids early epithelialization of the skin margins, resulting in a dry incision as the best insurance against infection. Drains carry the risk of ingress of bacteria and should not be used.

[b]Mayo scissors, Baxter Healthcare Corp., Round Lake, IL.
[c]Marlex, Davol Inc., Cranston, RI.
[d]Ethilon, Ethicon, Inc., Somerville, NJ.
[e]PDS II, Ethicon, Inc., Somerville, NJ.

Figure 82–1.


A
Establishing flaps from
the fascioperitoneal sac
B
Intraperitoneal
placement of mesh
C
F. Farras

Postoperative Management

A sterile, self-adhering impervious drape[f] should be applied after skin closure to protect the incision during recovery from anesthesia. Thereafter, a sterile dressing next to the incision is covered with an abdominal wall support to keep the wound clean and to control edema and seroma formation. Several rolls of wide adhesive tape can be used to construct a body bandage. These patients sustain body wall pain, which can be alleviated by phenylbutazone therapy for 3 to 10 days. The occasional horse with a large defect repair may require a narcotic analgesic for 24 to 48 hours after surgery. After herniorrhaphy, horses can be returned to normal feed the day after surgery, but stall confinement with no more than limited, in-hand exercise is mandatory for up to 90 days. The mesh does not provide wound strength per se but serves as a matrix for fibrosis. Complete strengthening of the fibrous tissue requires a year or more, and the patient can be lost to use in the interim.

The most serious complication of this surgery is infection. The risk of infection is increased by careless surgical technique or poorly timed surgery. The surgeon must be prepared to counsel the overanxious owner to wait for complete resolution of previous infection and for complete healing of traumatically induced body wall defects. Subsequent adhesions followed by secondary small bowel obstruction has been reported[5] but is rare and need not be a reason for avoiding surgery. Although these surgeries are uncommon, they can be rewarding and provide for an excellent outcome.

[f]Ioban 2 antimicrobial film, Animal Care Products, 3M Health Care, St. Paul, MN.

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Integumentary Surgery

chapter 83

Pinch Grafting

Horses often receive avulsion wounds, with extensive loss of skin and soft tissues, which must heal by second intention. This process may be slow, particularly on the lower limbs and over joints, such as the hock, where motion is constant. Second-intention healing of wounds by epithelialization and contraction can be assisted by skin grafts. Skin grafts may shorten the healing time in large wounds by as much as 80%.[1] The indications for skin grafts in horses include wounds with insufficient skin for primary closure, large extensive wounds that cannot heal completely by contraction and epithelialization, old chronic wounds in which the granulation bed is not vital and for which contraction and epithelialization have ceased, and the control of exuberant granulation tissue.

Free autogenous grafts are used most commonly in horses. Full-thickness sheet grafts, split-thickness sheet grafts, mesh grafts, tunnel grafts, punch grafts, and pinch grafts have all been used.[2] Pinch grafts, also known as seed grafts or pocket grafts, are small disks of skin harvested by cutting an elevated pinch of skin off at its base perpendicular to the pinch. These small disks are then implanted into pockets created in the recipient granulation tissue of the wound. Pinch grafts decrease inflammation, diminish infection, provide multiple new sources of epithelial tissue in the wound, inhibit exuberant granulation tissue, stimulate epithelialization around the wound margins, and promote contraction of wounds.[3] The advantages of pinch grafts include the following: (1) the grafting procedure can be done on the standing horse; (2) the procedure is easy to perform and requires no special skills or equipment; (3) grafts are resistant to infection and can withstand limited movement of the graft bed; (4) the donor sites heal readily; and (5) the procedure is inexpensive. The lone disadvantage of the pinch grafting procedure is that the resultant healed wound is not cosmetically pleasing. Wound surfaces often have a cobblestone appearance, and hair growth is sparse or nonexistent.

Topical irritants, lack of debridement, infection, and presence of old granulation tissue resulting from a long period of time between injury and grafting will cause the granulation tissue to be unsuitable for grafting.[4] Successful pinch grafting requires healthy granulation tissue. Healthy granulation tissue should be moist, pink, firm, and devoid of crevices. Surface contamination of healthy granulation tissue is inevitable. Most resident bacteria in granulation tissue are innocuous to skin grafts.[3] Severely infected granulation tissue should be treated before grafting. Infected granulation tissue is dark pink or purple, is friable, and has large amounts of surface exudate. Bleeding from infected granulation tissue is dark or venous in character. Infected granulation tissue, particularly tissue infected with *Streptococcus* spp, *Proteus* spp, or *Pseudomonas* spp, will not support pinch grafts.

Anesthesia, Positioning, and Surgical Preparation

Exuberant granulation should be trimmed 24 to 48 hours before grafting to allow a fresh, finely granular, vascular surface to re-form before grafting. Chronic wounds, with highly fibrous, white, dense granulation tissue, devoid of new capillaries, should be debrided 5 to 7 days before grafting to allow new healthy granulation tissue to form. Infection can be controlled by removing surrounding hair, surface debridement of the infected tissue, gentle cleansing and lavage with sterile

saline, medicating the wound with topical antibiotic preparations, and covering the wound with a nonadherent pad and bandage. Debridement of granulation tissue and excision of exuberant granulation tissue require no local anesthesia because granulation tissue has no nerve supply.

Pinch grafting can be done with the horse sedated and standing. The granulation tissue should be gently cleansed in preparation for grafting. No local anesthetic is used at the recipient site. Any area on the trunk of the horse where the skin is relatively thin can be used as a donor site. The donor site we prefer is just ventral to the fold of the flank. The hair should be removed with clippers and the skin surgically prepared. A ring block in the subcutaneous tissues with local anesthetic is used to desensitize the donor site. We anesthetize an area approximately 6 × 6 inches square. Larger donor sites may be necessary when harvesting more than 100 grafts. After anesthetizing the donor site, a final surgical scrub is placed on the skin to be harvested for grafts.

Surgery

Using a no. 15 scalpel blade, the surgeon creates pockets in the granulation tissue bed just below the surface, keeping the handle of the blade nearly parallel to the wound (Fig. 83–1*A*). The pockets should be made 1 cm apart over the entire wound and should be 0.5 × 0.5 cm in size. All pockets should open upwardly. After the pockets are made, pressure should be placed on the granulation tissue bed for 3 to 5 minutes to reduce hemorrhage. Pressure can be accomplished by hand pressure or by a temporary bandage. Grafts placed in pockets that are bleeding profusely will tend to "float" out of the pocket.

The pinch grafts are harvested by using a small rat-tooth forceps or fine Brown-Adson forceps[a] to grasp the skin, tent it, and pull it away from the flank. A small 2- to 3-mm-diameter disk-shaped piece of skin is excised with a sharp scalpel blade (Fig. 83–1*B*). This disk of skin is thicker at the center and tapers in thickness at the edges. Eight to 10 small pinches of skin are placed on a saline- or blood-soaked gauze sponge and transferred to the recipient wound bed. Remaining blood clot is removed from the pocket before the pinches of skin are implanted. The pinches are placed into the pockets with the epithelial surface facing outward. Hair direction is not important. Grafts are flattened when necessary and inserted by being placed on the granulation surface above the pockets and then pushed into the pocket with the tip of a small hemostat or with a closed forceps (Fig. 83–1*C*). When the pinch grafts are grasped by the teeth of the rat-tooth or Brown-Adson forceps and placed into the pockets, they are difficult to release because the forceps does not open fully. Grafts inserted in this manner often come out of the pocket when the forceps is withdrawn. Harvesting 8 to 10 pinch grafts and inserting them into the pockets of the granulation tissue bed continues until all pockets are filled. Gauze sponges are used to gently clean the granulation tissue surface of blood clots. Care must be taken not to push the pinch grafts out of the pockets. Limb wounds are covered with sterile nonadherent wound pads and bandaged. The bandage should not put pressure on the granulation tissue. Wounds on the back, thorax, or other area that cannot easily be bandaged are left open.

Postoperative Management

Horses should be confined to a box stall to reduce movement of the grafted wound. Bandages should be maintained for 3 to 4 weeks, at which time, if the grafting is successful, epithelialization will be extensive.

The frequency of bandage changes depends on the condition of the grafted wound bed. The first bandage change for a healthy noninfected granulation tissue bed should occur at 4 to 5 days. Exudate should be gently wiped from the surface so as not to dislodge the pinch grafts from the pockets. Infected wounds produce large amounts of exudate, which is detrimental to graft survival. Bandages over infected wounds should be changed every 1 to 2 days to remove the exudate.

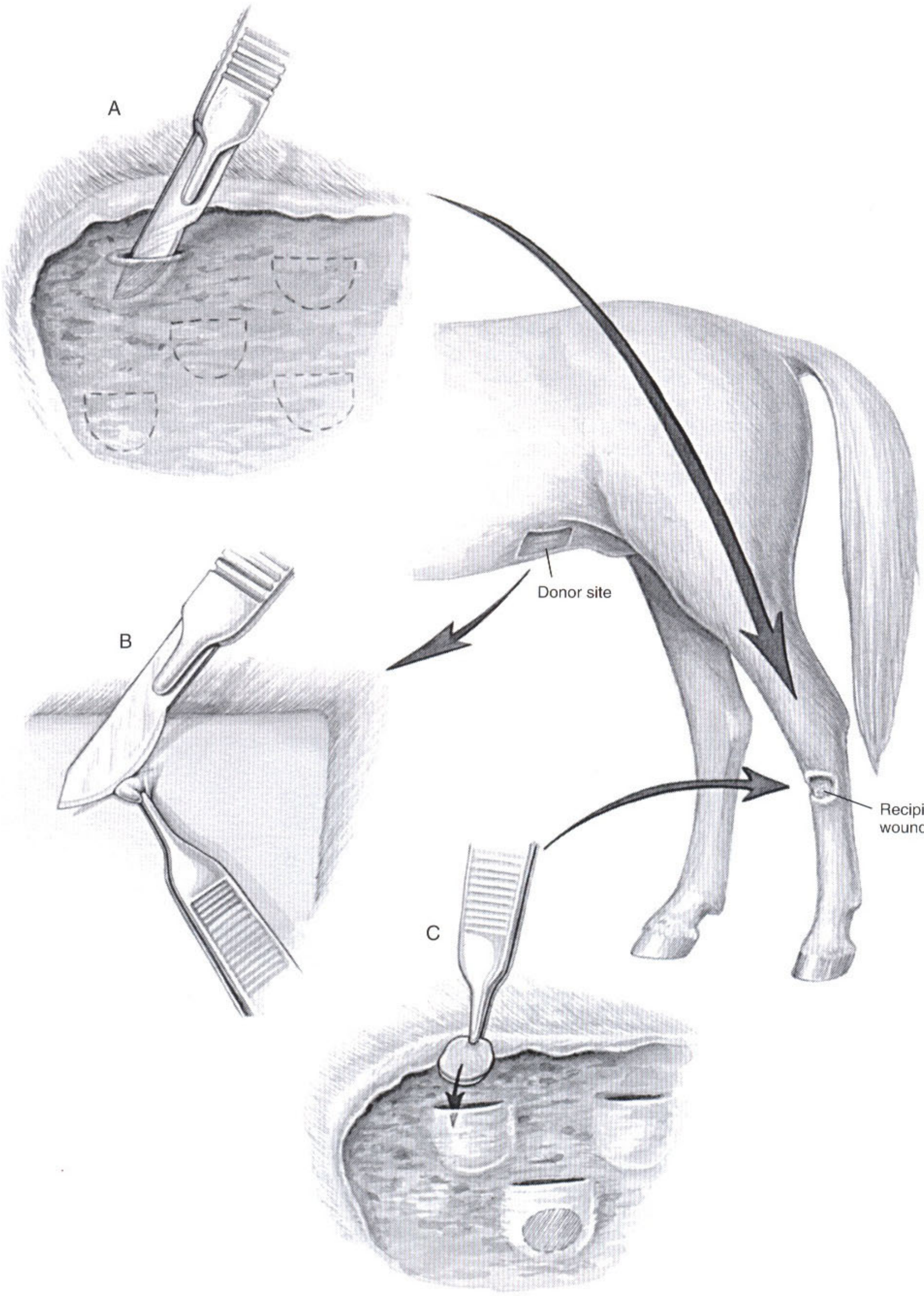
Typically, 65 to 75% of the pinch grafts survive. Grafts that survive can be identified at 2 to 3 weeks by the light pink epithelial tissue that migrates centrifugally from each viable pinch graft. Coalescence of epithelium from numerous grafts can rapidly cover the granulating wound. The grafts also stimulate peripheral epithelialization and contraction. Our experience with old chronic wounds is that a lower percentage of grafts survive, but the grafting procedure stimulates many of these wounds to contract. Pinch grafting can be repeated in 3 to 4 weeks when necessary.

[a]Brown-Adson forceps, Miltex Instrument Company, Inc., Bethpage, NY.

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Figure 83–1.



chapter 84

Cosmetic Tail Amputation

Historically, equine tail amputation was performed crudely with docking shears (Fig. 84–1), some types of which were intended to be heated in a forge to sear the tissues. Perhaps these instruments and approaches were the reasons some states outlawed tail amputation in the horse. The decline in draft horse numbers after the introduction of the tractor reduced general societal concerns about these animals and the management practices of their owners. Currently, draft horse numbers are increasing again, and amputation of the tail is still being practiced by breeders and by some veterinarians who serve them. The laws on the books have been forgotten or are not being enforced by some states and municipalities. Few, if any, of these animals are exhibited in shows or sales with natural tails; thus, tail amputations are being done. The regulations vary from state to state, and some veterinarians refuse to perform amputation of the tail, in any species, for ethical or aesthetic reasons. However, modern methods of anesthesia and surgery should preclude criticism based on inhumane surgical methods.

A standard practice among draft horse breeders is to dock foals within a few days of birth using an elastrator band.[a] The hair is clipped at the site of band application to hasten the constriction and dropping off of the tail. Protection against tetanus must be ensured in foals subjected to elastration. Responsible owners defer elastration in foals born late in the spring, when fly maggot infestation could be a problem, and elect surgical amputation after weaning (LLE Hale, personal communication, 1996). Although uncommon, diseases and injury of the tail would be other indications for surgical amputation.

[a]Elastrator, Nasco, Fort Atkinson, WI.

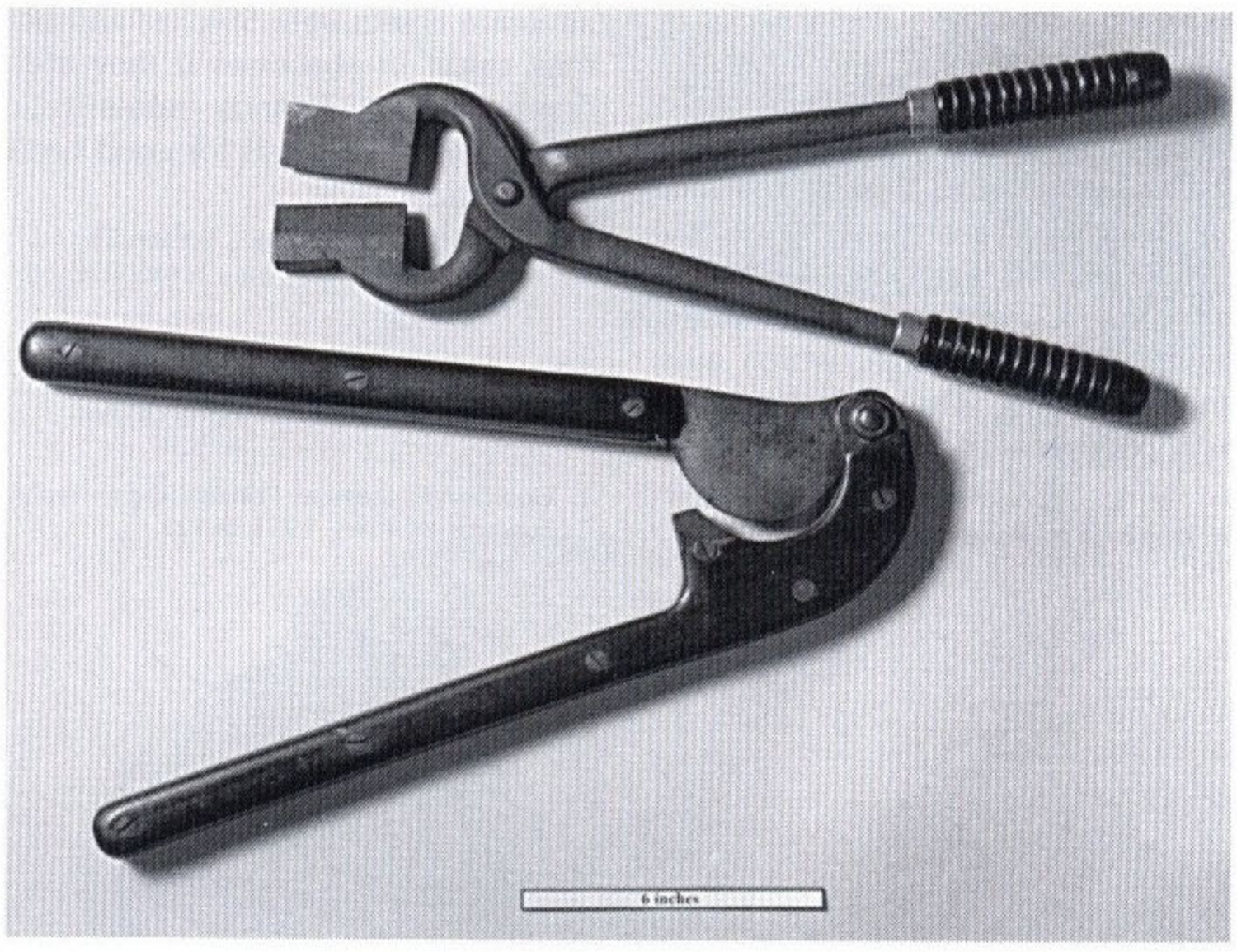


Figure 84–1.

Two types of antique tail-docking shears. The upper shears were intended to be heated in a forge.

Anesthesia, Positioning, and Surgical Preparation

Horses are operated in the standing position using epidural anesthesia. Stocks and chemical restraint facilitate the procedure. The epidural site, between the last sacral and first coccygeal vertebrae or between the first two coccygeal vertebrae, is clipped and routinely prepared for aseptic placement of an 18-gauge, 1.5-inch needle (see Chapter 2). Three to 5 ml of 2% mepivacaine hydrochloride,[b] injected into the epidural space, provides sufficient anesthesia in weanling horses. Older animals may require an additional 2 to 3 ml of local anesthetic solution. Local infiltration of anesthetic solution at the amputation site is a suitable alternative to epidural anesthesia. Local infiltration creates tissue edema, which aids in the control of hemorrhage after surgery.

We request the owner to specify the desired tail length; usually, this is at the level of the ventral commissure of the vulva in females or just below the ischial arch in males. The long hair above the site is turned up and bandaged above the intended incision line (Fig. 84–2*A*). Gum rubber tubing is used as a tourniquet at the base of the tail. The remaining hair is clipped, and the tail is routinely scrubbed for aseptic surgery. Draping is unnecessary, but the surgeon should don sterile gloves and use autoclaved instruments.

Surgery

Two large semicircular flaps of skin and coccygeal muscle, one dorsal and one ventral, are fashioned to create the designated tail length at a point just distal to the level of vertebral disarticulation (see Fig. 84–2*A*).[1] The flaps should be about as long as the tail is wide. The dorsal flap can be slightly longer than the ventral flap. The scalpel is held firmly, and the tissues are incised down to bone. The skin of the flaps is incised at an angle, establishing a beveled edge, which aids suture approximation and healing. The scalpel is used to incise the remaining coccygeal musculature sharply, elevating the flaps, and the tail is flexed to identify the intervertebral prominence at the level of amputation. Occasionally, the appropriate intervertebral prominence is proximal to the flaps and inaccessible for disarticulation. The flaps can be enlarged by extending the lateral incisions proximally for 1 to 2 cm. The tail is amputated by transecting the relatively thick intervertebral fibrocartilage (Fig. 84–2*B*). No effort is made to identify and ligate the coccygeal vessels. When severed, they recoil into the fascia and are inaccessible. Depending on the size of the tail, three to five mattress sutures of size 1 or 2 nylon[c] are placed through the flaps distal to the last remaining coccygeal vertebrae (Fig. 84–2*C*). In addition to approximating the flaps, these sutures help to control bleeding. Size 0 polypropylene[d] simple interrupted sutures are used to approximate the beveled skin margins (see Fig. 84–2*C*).

Postoperative Management

The tourniquet and bandage are removed 20 to 30 minutes after surgery, allowing the long hairs to cover the stump. The horse should be kept calm and undisturbed after surgery to minimize bleeding. Most horses drip some blood from the incision; bleeding usually stops spontaneously within 8 or 10 minutes. Excitable horses may bleed profusely, requiring reapplication of the tourniquet for a 15- to 30-minute interval. Reapplication of the tourniquet usually is sufficient to control hemorrhage in troublesome cases. Except for removal of the sutures at 12 to 14 days, no further aftercare is required. Stitches will become infected and may result in abscesses if they are not removed in a timely fashion. Tetanus immunization status must be current. The prognosis for good healing is excellent.

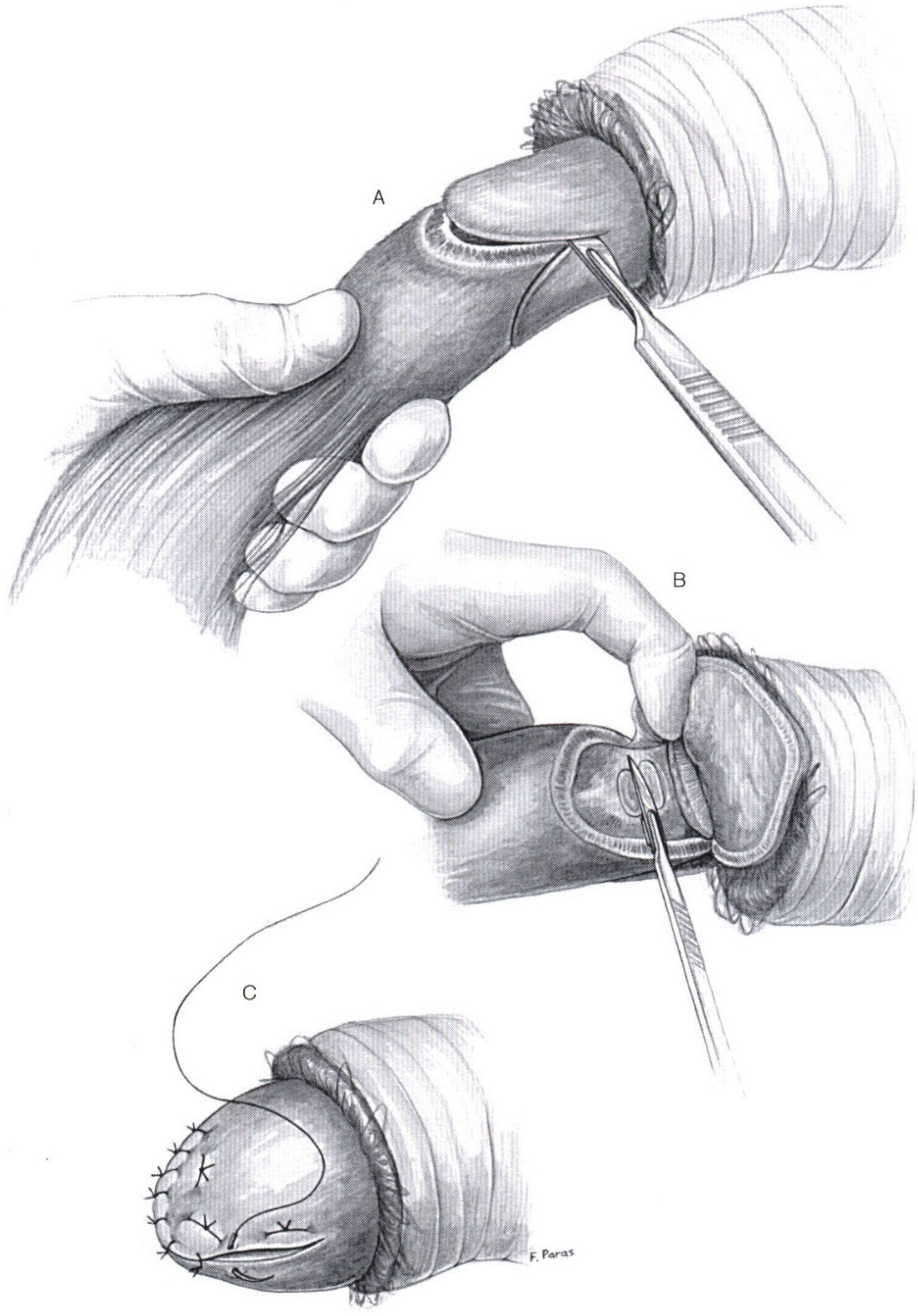
[b]Carbocaine V, The Upjohn Co., Kalamazoo, MI.

[c]Ethilon, Ethicon, Inc., Somerville, NJ.
[d]Prolene, Ethicon, Inc., Somerville, NJ.

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Figure 84–2.



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